POWER PLANT ENGINEERING

GENERATION, TRANSMISSION AND UTILIZATION OF STEAM, ELECTRIC, DIESEL AND HYDRAULIC POWER

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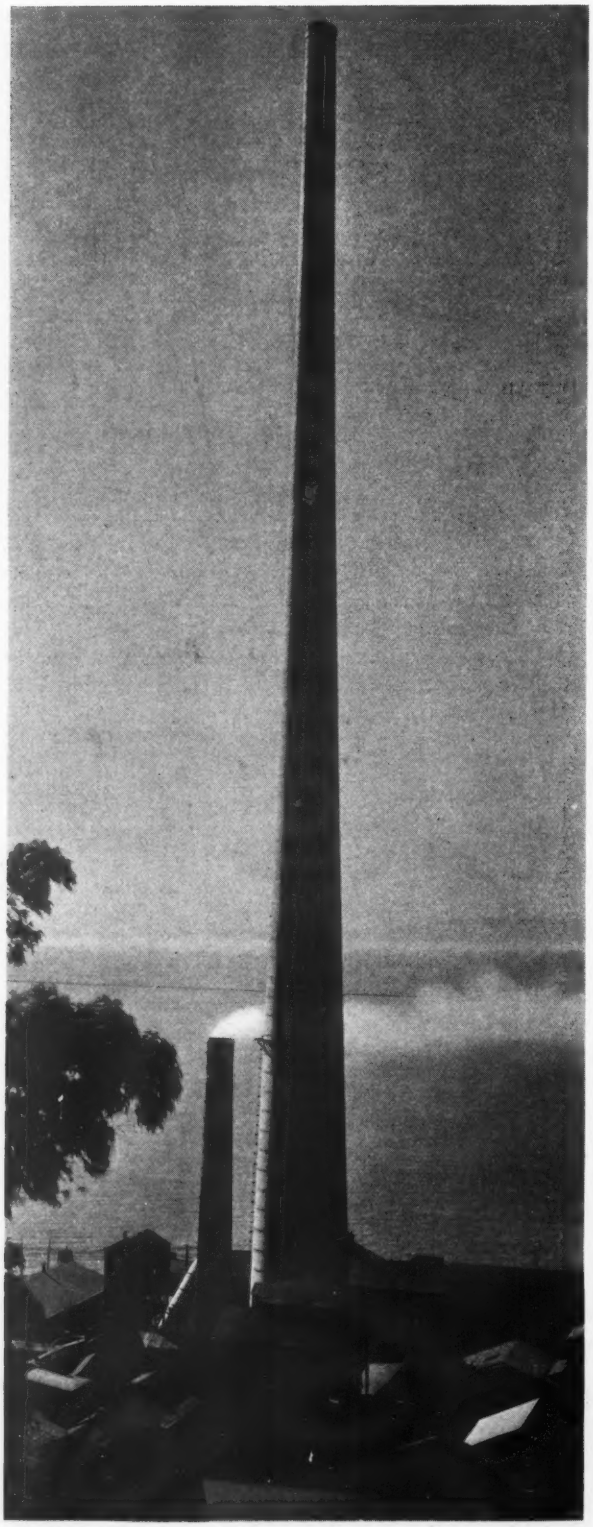
Here's Another



PICTURES of the World's Tallest Chimney are becoming almost proverbial—if pictures can become proverbial. Every once in a while we see a new one. For a number of years if our memory serves us correctly the World's tallest chimney was in Montana, then in Japan—it seems there were several there. Just a year ago, in fact, in the April 1937 issue we published a picture of the latest World's tallest, this one in Korea and said to be 618 ft. high but only 600 of the feet were actually above the foundation.

Now, C. W. Geiger our live-wire correspondent in San Francisco sends us the picture of the chimney shown here and says that it is the tallest in the world. Well, knowing Mr. Geiger as we do, and since he says it is 605 ft. high above the foundation, it must be true—it tops the one we described last year by five feet and five feet are five feet whether they are in Korea or San Francisco. One just cannot ignore facts. As Mr. Geiger puts it, "this chimney is 605 ft. in height—making it the world's tallest and thereby adding another monumental landmark in the San Francisco Bay area."

As in the case of all these tall chimneys, this one serves a smelting plant—the Selby Plant of the American Smelting and Refining Co. It is constructed of concrete and was built with the Alphons Custodis Chimney Construction Company's patented all-steel forms in sections 7 ft. 6 in. high. Its weight above the foundation is 5200 tons. The extreme top is surmounted by a ceramic cap anchored to the chimney with Monel metal anchor bolts, and the top 300 ft. on the outside is treated with three coats of silicate of soda applied in dilute solutions.

A lightning rod system of 6 points around the periphery of the top is connected to three down leads of 5/8 inch heavy stranded copper cable. These cables are interconnected at 50 ft. intervals. The points are 3/4 in. solid copper rods. Each downlead has its own grounding system consisting of three copper covered grounding rods 3/4 in. dia. and driven into the ground 10 ft.

An interesting fact concerning the construction of this great stack is that though it involved a total of 15,000 man hours of work there were only six minor injuries, the most serious of which was a slight laceration of the head.

The chimney has a capacity of 208,000 cu. ft. of gas per minute. The data here presented was furnished through the courtesy of C. C. Moore & Co., the Alphons Custodis Chimney Construction Co. and the California State Industrial Accident Commission.

WITH THE EDITORS

Future Power Stations

CHANGES in amounts and occurrences of peak loads are altering demands on power stations so that future designs may be materially changed. Formerly a high peak in the late afternoon, with fairly steady demand, except during noon hour, for the rest of the day, and little or no load nights and Sundays made up a typical load curve. With increased domestic use, especially of washers, refrigerators, cooking and water heating, although there is still an evening peak, conditions are otherwise quite different. While commercial load has perhaps doubled or trebled, domestic load has increased seven to eight times, so that, in many cases it is half or more of the total load. While refrigerators are fairly steady, washing, ironing and cooking produce sharp peaks of their own, but not, except evening cooking to some extent, concurrent with other peaks. This tendency seems likely to increase and to affect to a considerable degree the design of power stations. In a recent address before a chapter of the Institution of Electrical Engineers, D. H. Parry called attention to some of the problems.

For a large network, three classes of service are required: Base load stations to operate continuously; day load equipment for the steady day load, to be shut down at night; peak load equipment to be run for short periods as needed. In the Central England network, 50 per cent of maximum demand and 80 per cent of output is from base load stations; day load equipment furnishes 30 per cent of maximum demand and 18 per cent of output; peak load is 20 per cent of maximum demand and only 2 per cent of output. It is noteworthy that in residential districts the Sunday load is from 85 per cent to 230 per cent of the week day load, but, of course, the commercial load is reduced to nearly nothing on Sundays.

Obviously, base load equipment must be provided to run every day in the year, with as great capacity in summer as in winter and with high efficiency and dependability. Cost will be subordinate to these considerations. Only so much spare capacity is needed as will provide for periodic inspection and overhauling. Since load is steady but variable, governing to control by-pass or extra nozzle control will be needed.

For day load, requirements are about the same but, as units will be started or shut down as needed, hence will always operate at near capacity, governing need not include by-pass or nozzle control.

Peak load units, to run for short periods every day, should be reliable, simple, quick starting and as efficient as possible at full load, consistent with low cost. Use factor will be low, hence large expenditure to secure slight gain in efficiency will not be justified.

High pressure, high temperature, reheat and stage heating of feedwater will, of course, be used for base load and day load equipment. For peak load, Mr. Perry suggests a possible arrangement to supply process and heating steam during off-peak periods at moderate pressure from boilers that, during peak periods, could be run up to high pressure to supply "top plant" generating units whose exhaust would give the process and heating steam.

Design to meet the new conditions will probably be quite different from former standards, especially as the continued increase of domestic load is liable to carry the peak load to 40 per cent of maximum demand and 15 per cent of output within a few years.

Artificial Light in Greenhouses

FOR SOME TIME it has been known that small quantities of artificial light has a material effect on growing flowers and its use in commercial greenhouses is now quite common. Light may be used to hasten the blooming of some plants and retard the blooming of others, depending upon the amount of sunlight that these plants ordinarily receive during their normal blooming period. Artificial lights may be used to lengthen the period of daylight or they may be used at any time during the night, as it has been found that the blooming time is controlled largely by the total number of hours of light rather than by the intensity.

Flowers which bloom in the spring and fall normally receive about 8 hr. of sunshine while those which bloom in the summer receive 14 to 15 hr. Summer plants may be made to bloom early by supplementing daylight. Short-day plants, for instance the chrysanthemum, may be made to bloom in August and September by shading them with a dark cloth and decreasing the normal period of daylight during the summer, or, they may be made to bloom in December or January by use of supplementary lighting during the growing period.

Besides making greenhouses independent of weather conditions, artificial light has been found to have beneficial effects on the general health of the plant and particularly on what is known as "bud drop" on plants such as the gardenia and sweet pea which have a tendency to drop their buds after a period of unfavorable light conditions.

Work on a commercial scale has resulted in the development of special lights and lighting fixtures for use in the home. These are designed to make excellent reading lamps, complying with the I. E. S. specifications, and at the same time concentrate sufficient light on plants to enable them to grow in locations removed from windows. It has been found, however, that the artificial light is not a complete substitute for sunlight and must be considered as a supplementary control method rather than a complete treatment. It is, however, indicative of the influence electric power is having on all phases of commercial and home life.

POWER For Motor and

New manufacturing unit of the General Motors Corporation near Buffalo purchases electric power but incorporates a large pulverized coal fired steam plant for supplying steam for heating and process work as well as compressed air.

AS A further step in the extension of the manufacturing facilities of the General Motors Corp. "Chevrolet" has recently completed and placed in operation an entirely new motor and axle plant near Buffalo, New York. This plant which is located at Tonawanda on the Niagara River represents the last word in automobile manufacturing practice. It is equipped with every modern machine and tool available to the industry and incorporates in its layout every known method and arrangement for obtaining flexibility in manufacturing operations. Finally, it is designed for the utmost safety, convenience and efficiency of the employees.

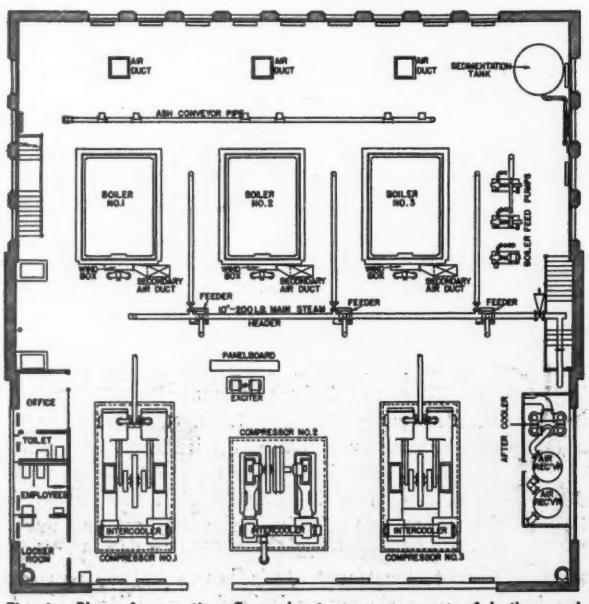


Fig. 1. Plan of operating floor showing arrangement of boilers and compressors

Electrical energy for operating this huge plant is purchased from the utility operating in that area but the project involves a power plant of considerable proportions to supply steam for heating and process work and compressed air for general service. This power plant is a separate building located some distance from the factory buildings but connected thereto by an underground tunnel which carries the steam, gas, water, condensate and compressed air lines.

This plant, though not characterized by any unusual operating conditions or principles of design, is highly representative of good modern power plant practice and a brief description of its general features should, therefore, be of interest.

As shown by the accompanying drawings the main equipment consists of three pulverized coal fired boilers, operating at about 175 lb. pressure, and three large air compressors, two of which are steam driven and one motor driven. The steam driven compressors are furnished steam at boiler pressure and exhaust against a back pressure of 20 lb., this exhaust being used at this pressure in the unit heaters which heat the factory, and also for process work.

The arrangement of equipment is simple and convenient. The boilers are arranged on one side of the building and the air compressors on the other, with no curtain wall between the boilers and the compressors. The boilers face the compressors and the coal bunkers and the pulverizing machinery occupy the central portion of the building as shown on the cross section. The design of the building is uniform with that of the factory, the outside being of yellow pressed brick, with large windows on all sides.

The boilers are Union Iron Works units, Type N-A,

Chevrolet's New Axle Plant at Buffalo

built for 200 lb. working pressure and equipped with Bigelow Liptak suspended walls and with dry bottom ash pits. Each of these units has a total heating surface of 7530 sq. ft. and is capable of delivering from 10,000 to 65,000 lb. of steam per hr. All pulverizing equipment as well as the coal burners and feeders are of Kennedy-Van Saun manufacture.

Coal Handling

Coal is delivered to the plant by railroad cars and dumped into a large track hopper, to a crusher and feeder conveyor which delivers to a vertical bucket elevator. This elevator in turn feeds the traveling belt above the coal bunkers. All conveyors are interlocked but the crusher can be taken out of the line or interlocked in as desired.

This much of the coal handling system is perfectly standard and requires no comment, but the arrangement between the coal bunker and the pulverizers is somewhat different. The coal bunker, as will be noted, extends the entire length of the boiler room above the coal scales and pulverizer feeders. Coal can, therefore, fall by gravity directly into the coal scales and spouts are provided to permit this, but these only permit using the coal directly above the openings. In order that the coal in other parts of the bunker may be withdrawn, a lateral scraper conveyor system is installed below the bunker which takes coal from some 17 openings along the length of the bunker. The arrangement is somewhat as shown in Fig. 4. The scraper conveyor is controlled entirely by the automatic coal scales but it can also be operated manually and independent. When any of the three scales demand coal, contacts are closed which start the conveyor motor and this then continues in operation as long as one of the three scales needs coal. Two ports or passages are also provided between the upper and lower runs of the conveyor to by-pass coal from the top to the bottom run to avoid carrying coal the entire length of the conveyor under certain conditions of operation. These ports can be closed or opened by the operators as desired.

From the coal scales, the coal drops into a revolving type feeder which feeds the pulverizing mills installed on the basement level. The feeders are simple in construction and operation, consisting merely of a slowly rotating horizontal disc upon which the coal falls and is pushed off by a deflecting vane the angle of which may be varied to control the rate of feed. The advantage of this feeder is that it will pass large pieces of coal or foreign material and since such foreign matter can do no harm in the ball mills, the whole makes an extremely satisfactory arrangement.

Each boiler furnace has two pulverized coal burners installed one above the other in the front wall and one combination gas and oil burner. The latter is used for starting on gas and for utilizing oil waste from the factory. A manufacturing plant of this character uses an immense quantity of lubricating oil in the machine tool operations. This oil is reclaimed and used over and over but there comes a time when it can no longer be used for machine operations and then it is sent to the power plant to be burned. While the amount of such oil naturally is small when considered as a source of

Fig. 2. A view of the office building at the new Chevrolet plant. There offices are heated by a hot water heating system supplied from a heat exchanger using low pressure steam

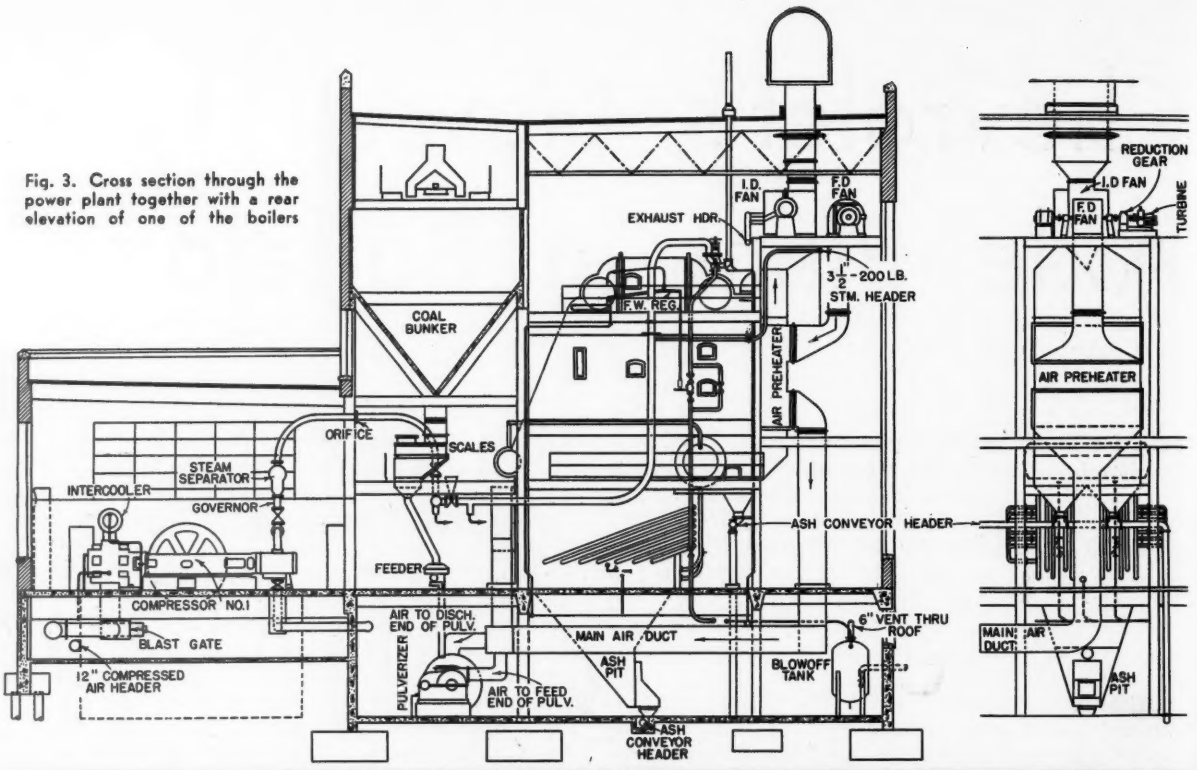


Fig. 3. Cross section through the power plant together with a rear elevation of one of the boilers

fuel, still there is enough probably to carry the plant on extremely light loads. If desirable, a small additional amount of fuel oil may be purchased for operating the plant on oil under such conditions of light load.

As shown by the drawings, each of the three boilers has its own coal scale, fuel feeder, pulverizing mill and exhauster. The mills and exhausters are located in the basement.

Control of the boilers is all from the main operating floor where the combustion control panels are located. Combustion is controlled automatically by means of the Republic-Smoot system which of course also permits manual operation if desired. The combustion control board consists of four panels, one main control panel and three boiler panels, containing the multipointer draft gage, steam flow meter, CO_2 recorders and push button controls for each boiler.

Both the forced and induced draft fans are located high up above the rear of the boilers just below the breeching to the stack. The arrangement is clearly indicated in Fig. 6 which also shows the air ducts to and from the air preheater. Both the forced and induced draft fans are Clarage fans, driven through Falk reducing gears by Whiton turbines, on one side and Westinghouse induction motors on the other side so that either steam or electric drive can be used.

Ash which is withdrawn from the ash pits in the basement is removed by a steam jet conveyor and delivered to a storage bin outside of the building.

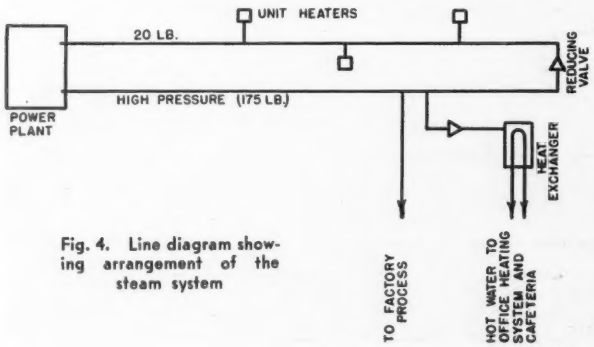


Fig. 4. Line diagram showing arrangement of the steam system

Water System

Water for the entire manufacturing plant including the boiler plant with the exception of the water used for drinking water which is city water, is obtained from two deep well pumps near the river. A pump house is located at the river which houses not only these pumps and their motors but also traveling screens and filters through which the water passes before entering the system supplying the plant. This is a single system with lines leading to hydrants, toilets, process equipment, etc., throughout the factory. One line runs to a large storage tank mounted at the top of a steel supporting structure adjacent to the boiler house. The water level in this tank controls the operation of the pumps in the pump house by an altitude switch, an arrangement which provides a constant "head" on the system.

For use in the Boiler Plant, water from this system passes through a Permutit hot process softener and sand filters, then is pumped by two float controlled soft water pumps to the condensate tank which is placed above the deaerating heater. These pumps maintain the water level in the condensate tank. The softened water along with the condensate returns, then flows to the deaerating feed water heater. All high pressure drips connect

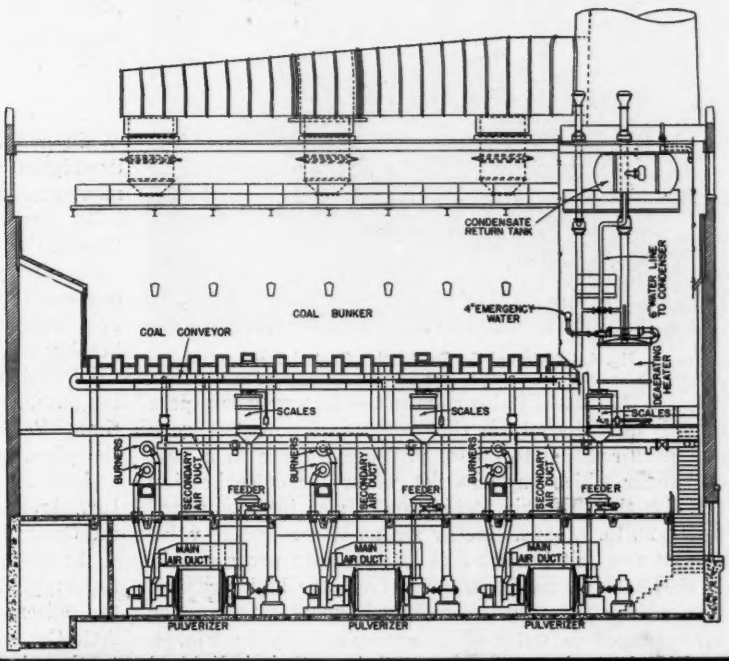


Fig. 5. Longitudinal section through the boiler room showing the method of handling coal to the mills. A horizontal scraper conveyor runs the entire length of the room underneath the coal bunker. This conveyor takes coal from openings along the entire bottom of the bunker and delivers it, from the lower run, to the three coal scales. By-pass openings permit coal to drop from the upper to the lower run without having to travel the entire length of the conveyor when serving the two right hand scales

directly into the heater. All 20 lb. drips from the low pressure steam system discharge into a small condensate tank in the basement from which a float controlled pump in turn delivers it to the main condensate tank installed above the feed heater. The deaerating heater is an Elliott tray type unit with a capacity of 200,000 lb. per hr.

The feed water is heated by exhaust steam from the steam driven auxiliaries and delivered to the boilers by three centrifugal boiler feed pumps, one electrically driven and two steam driven. These are Worthington units, one coupled to a 50-hp. Wagner induction motor and the other two to 50-hp. Whiton turbines. The feed water flow to the boiler is regulated by Copes regulators.

As already mentioned, steam is generated at a pressure of 175 lb. It is used at that pressure in the steam driven air compressors and by the boiler plant auxili-

Principal Equipment in the Power Plant of The Chevrolet Motor and Axle Co.

GENERAL

Location, Tonawanda, New York
Owners, Chevrolet Motor Co.
Designers, Albert Kahn, Inc., Detroit, Mich.
Type Plant, Industrial—automotive manufacturing

BOILER EQUIPMENT

Boilers. 3, Union Iron Works, Type N-A, designed for 200 lb. w.p., 7530 sq. ft. H. S., 10,000 to 65,000 lb. per hr. with Bigelow-Liptak suspended walls and dry bottom ash pits. Furnace fitted with Bigelow-Liptak type 114-4 Pyrex furnace observation doors.
Pulverized Coal Burning Equipment. Kennedy-Van Saun Mfg. and Eng. Corp. 3 revolving type feeders, each operating through a Reeves variable speed motor unit, 3 Kennedy-Van Saun Gearless "Airswept" Tube Mills driven through Philadelphia Gear Works reduction gears by Westinghouse 60 hp. induction motors, 3 K-VS coal exhausters driven by 10 hp. Westinghouse variable speed slip ring motors, 6 (2 per boiler) K-VS pulverized coal burners.
Gas and Oil Burners. 3 (1 per boiler) Forney Engineering Co. combination gas and oil burners.
Air Pre-heaters. Union Iron Works, straight tubular.
Induced Draft Equipment. 3 Clarage Fan Co., type R.T. size 7 fans driven through Falk Corp. reduction gears by (1) 30 hp. Westinghouse induction motor and (2) by 30 hp. 175 lb. press. D. E. Whiton Machine Co. steam turbine.
Forced Draft Equipment. 3 Clarage Fan Co., type W, size 2¼ fans driven through Falk Corp. reduction gears and driven (1) by 30 hp. Westinghouse motor and (2) by 32 hp. D. E. Whiton Machine Co. 175 lb., 3500 r.p.m. steam turbine.
Breeching. Michigan Boiler and Sheet Iron Co.
Stack. Reinforced concrete, 200 ft. from operating floor, fire brick lined. Rust Engineering Co.
Boiler Accessories
Crosby steam pressure gages
Diamond Valv-in head soot blowers
Consolidated safety valves
Copes (Northern Equipment Co.) feed water regulators
Reliance gage columns with high and low level alarms and with Prismatic Periscope Head
Eckenroth blow-off valves
Combustion Control. Republic Flow Meters Co. Smoot combustion control and control panels and instruments.
Boiler Feed Pumps. 3 Worthington Pump and Machinery Corp. centrifugal units. 2 driven by D. E. Whiton Machine Co., 50 hp., 3500 r.p.m., 160 lb. press. turbines and 1 by a 50 hp., 3500 r.p.m. Wagner Electric Co. induction motor. Badger expansion joints used between pumps and water lines.
Feed Water Heaters. Elliott Co. tray type, 200,000 lb. per hr. capacity.
Water Treatment. Permutit Co. hot process softener with Permutit sand filters.
Pumps
2 Weil Pump Co. centrifugal pumps for pumping softened filtered water to condensate tanks, each driven by a 5 hp. Westinghouse motor
1 Weil Pump Co. centrifugal pump for pumping water from city water storage tank to softener, driven by 10 hp. Westinghouse motor
2 Weil, vertical sump pumps driven by Westinghouse motors

COAL AND ASH HANDLING

Coal Handling Equipment. Robins Conveying Belt Co. Track hopper, crusher, feeder, vertical bucket elevator, belt distributing conveyor above bunkers, and lateral conveyor below bunkers. All driven by Westinghouse Electric & Mfg. Co. motors controlled by Westinghouse De-Ion line starters and Bulldog Electric Products Co. safety switches.
Coal Scales. Richardson Scale Co. automatic electric coal scales equipped with Allen Bradley, line switches and Trumbull Electric Mfg. Co. thermostatic motor switch.
Ash Handling. Nuveyor pneumatic ash and fly ash conveyor. Ash storage tank with rotary ductless unloader. Refractory lined ash pit hoppers under furnace bottoms. United Conveyor Corp.
Air Compressors. 2 Worthington Pump and Machinery Corp. 3000 c.f.m. steam driven. 1 Ingersoll-Rand 3000 c.f.m. unit driven by 500 hp. 100 per cent power factor, 440 v. Electric Machinery Mfg. Co. synchronous motors.
Exciter for Compressor Motor. Electric Machinery Mfg. Co. 15 hp., 440 v. induction motor direct connected to a 7½ kw., 1750 r.p.m., 125 v. d.c. generator.
Synchronous Motor Control. Electric Machinery Mfg. Co. frequency responsive control.
Compressor Lubricators. Manzel & Bowser forced feed.

MISCELLANEOUS EQUIPMENT

Relief Valves. Cochrane Corp. relief valves on 5 and 20 lb. exhaust lines.
Loading Pressure Compressor. 1 Curtis (St. Louis) compressor and receiver driven by 5 hp. Wagner Electric Co. motor.
Valves. Chapman Valves on all high pressure and low pressure steam and water lines. Crane valves on air compressor.
Traps. High pressure traps, Crane Co.
Electric Switches, Starters, Controllers
Westinghouse Electric & Mfg. Co.
Bulldog Electric Products Co.
Clark Controller Co.
Allen Bradley Co.
Piping. Republic Steel Corp.
Heating System. Sarco Company
Radiators. American Radiator Co.

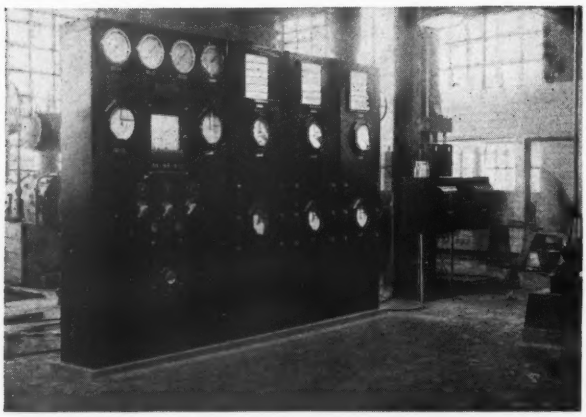


Fig. 6. A view of the Combustion Control Board

aries. A 175 lb. line also runs to the factory where part of it is used directly at that pressure for process work and part reduced to 35 lb. pressure for use in a heat exchanger which supplies hot water for office heating and for the cafeteria. This line is also interconnected to the 20 lb. exhaust line by means of a reducing valve so that the unit heaters and low pressure process main in the factory may be supplied from the high pressure line in case there is a scarcity of exhaust steam. The arrangement is outlined diagrammatically in Fig. 4.

The three air compressors each have their individual intercoolers and deliver into a common after cooler. The latter are installed along one wall of the compressor room adjacent to the two air receivers which are connected in series. The two Worthington steam driven compressors have capacities of 300 c.f.m. and the electrically driven Ingersoll-Rand machine, 3000 c.f.m. The latter is direct connected to a 500 hp., 100 per cent power factor, 440 v. Electric Machinery Co. synchronous motor. Excitation for this motor is furnished by a motor driven exciter set located back of the combustion control panel.

Conclusion

This completes the general description of this plant. While not spectacular, it will be apparent from this description and from the drawings showing the arrangement that the plant is well designed for the purposes it is to serve. The layout is simple and the equipment disposed in units such that any size load can be carried economically. By means of the combination of steam and electrically driven main units and boiler auxiliaries, the heat balance can be adjusted to almost any type of heating load, summer or winter.

At this writing it is too early to prevent any operating data, since the plant has only been in service a short time. Preliminary operation, however, indicates that the plant will fulfill the expectations of its designers and owners. The plant was designed by Albert Kahn, Inc., Architects and Engineers of Detroit, Michigan, for the Chevrolet Motor Co.

In closing we wish to extend credit to Albert Kahn for supplying the drawings used in this article and to the officers and engineers of the Chevrolet Motor and Axle Co. for many courtesies extended during our visits to the plant and in the collection of the data which forms the basis of this description. The plant is being operated under the direction of A. G. Gulliver, plant manager, with A. A. Way, Supt., and J. V. McCall as plant engineer. S. C. Mercer is chief engineer of the power plant.

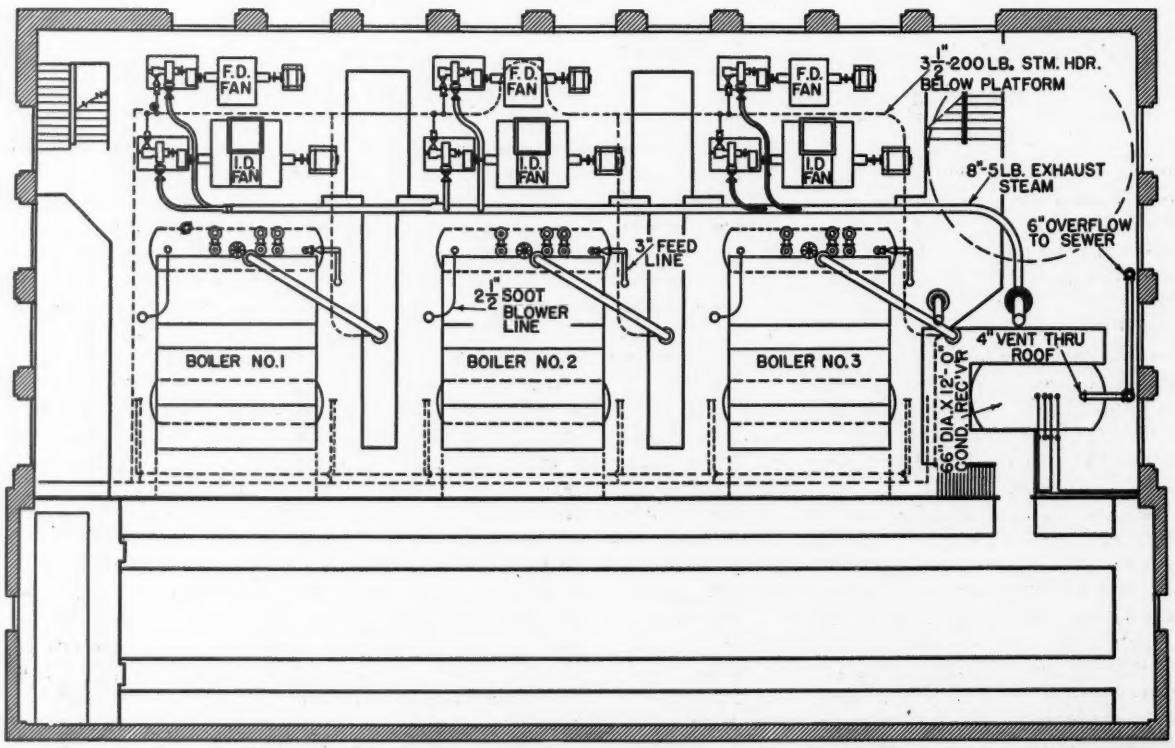


Fig. 7. Plan above boilers showing arrangement of forced and induced draft fans

Effects of Unburned Combustible

An interesting discussion of the effect of unburned combustible on the design and performance of steam generating equipment.

By
G. Campbell Kohlar

A PROMINENT FAN MANUFACTURER was perplexed. He had before him the predicted gas weights, excess air and fuel for a new boiler that was soon to be built, his engineers had computed the gas weight to be expected from the given fuel, and had found that with no excess air at all the resulting gas weight was higher than that submitted by the boiler manufacturer, who had used 30 per cent excess air. The answer laid in the failure of the fan designer to take the losses caused by unburned combustible matter into consideration. In all probability much oversized power plant equipment is built every year because this same factor is overlooked. The influence of unburned combustible matter is far reaching. It affects every piece of equipment from the grate to the stack. It may be the cause of many dollars being spent unnecessarily for fans, stacks, flues and ducts and even boilers which are larger than the job for which they are intended requires them to be.

Unburned combustible is responsible for some definite loss in every boiler furnace regardless of the fuel used. In some cases, as when firing with gas or oil, this loss becomes very minor, and even negligible. Units which are fired by pulverized coal or underfeed stokers have relatively small "carbon" losses, but not, however, small enough to be neglected. But traveling grate stokers are used, especially those burning the poorer grades of anthracite, serious errors in the design of new equipment, or in the performance calculations of existing equipment, may result from the neglect of this item.

Three factors enter into the products of combustion of any fuel; the portion of the fuel that is actually burned, the air supplied for combustion and the moisture in the air and in the fuel. Table I shows the calculations of the air necessary for, and the moisture resulting from the combustion of a Pennsylvania anthracite, the ultimate analysis of which is given in column one. Column three is the product of columns one and two; column five is that of columns one and four. The "free" oxygen in the coal is available for combustion, and so a quantity of air containing oxygen equivalent to the "free" oxygen must be deducted. Thus each pound of coal burned will require 8.935 lb. air and will form .311 lb. water vapor in the ideal case.

If 10 per cent of the carbon is unburned, either by running over into the ash pit or by going up the stack as fly ash or cinders, an amount of air which is less than the theoretical requirement by 10 per cent of 8.199 (Table I) is all that is necessary. The combining air contains about 0.13 lb. water vapor per pound of air at atmospheric conditions, and this moisture will also be found in the products of combustion. The gas weight per pound of coal is then computed as follows:

Theoretical air			8.935	8.935
Less air not required due to 10 per cent unburned carbon			.820	
			8.115	
Excess air 30%			2.435	2.681
Coal	1.000			
Minus ash	—.130			.870
Minus unburned C	—.071		.799	
Moisture in air	.013 × 10.550		.137	.151
Dry gas per lb. coal			11.486	12.637
Total moisture	.137 +	.311	—.448	.462
Dry gas per lb. coal			11.038	12.175

If the above computation is made, and the unburned carbon is neglected, the result would be 12.637 lb. wet gas, or 12.175 lb. dry gas per pound of coal fired. This is a difference of 1.15 lb. gas per pound coal fired, or for 5,000 lb. coal per hour it would mean an error of about 5750 lb. per hour, or 2300 C.F.M. in the gas weight. Table II gives a comparison of results obtained when firing coal at the rate of 5000 lb. per hour, and with the gases leaving the boiler at 500 deg. F.

TABLE I.

Ultimate Analysis.	Air lbs. per lb.	Air lb.	Water lbs. per lb.	Water lb.
S	.0051 × 4.32	.022		
H_2	.0236 × 34.35	.811	.894	.211
C	.7105 × 11.54	8.199		
H_2O	.1000	....		.100
N_2	.0083	....	...	...
O_2	.0225 × 4.32	—.097		
Ash	.1300	....	...	...
	1.0000	8.935		.311
B.t.u. per lb. as fired		11745		

What effect will these errors have on the design of the equipment through which the gas travels? It may be necessary to limit the draft loss through the boiler. Draft losses vary very nearly as the square of the gas weights, other factors remaining constant, so that the error involved in neglecting unburned carbon would show an apparent required draft 20 per cent higher than that actually needed. An oversized boiler may be specified, when a smaller one would suffice. Or a certain efficiency or exit gas temperature might be expected for a given rating. If these quantities are computed on a false weight of gas, the boiler obviously, will not perform as desired.

In heat transfer equipment of any type an important factor in design calculations is the "Water equivalent," which is the product of the weight of gas and its mean specific heat over the given temperature range. Thus the design of superheaters, economizers, air preheaters and similar units is seriously affected by a false gas weight. The cross-sectional area of flues and ducts, the height and diameter of stacks, the size and power requirements of forced and induced draft fans are similarly affected.

But, it will be argued, the above considerations apply principally to equipment design, and the designer should be responsible for the satisfactory behavior of his brain children. What does all this mean to the engineer who is operating and maintaining an existing plant? Here there are all sorts of meters and gadgets which show at a glance what conditions are. It is not necessary to compute the draft loss through the economizer, a manometer will do that more quickly than a slide rule. The stack is twenty feet higher than it ought to be, but what can be done about that now?

TABLE II.

	Carbon Loss Considered	Carbon Loss Neglected
Wet gas—lbs. per hr	57430	63185
Wet gas—C.F.M.	23450	25675
Dry gas—lbs. per hr.	55190	60875
Dry gas loss—% Eff'c'y	9.47	11.48
Loss due to H_2 and Moisture—% Eff'c'y	3.53	3.55
Total loss—% Eff'c'y	13.00	15.03

True. But power plants have a habit of growing old, and of not performing as was their wont. The management decides to rejuvenate the aging steam factory, and calls in its operating engineer. Plans are made to change this, remodel that, put a new baffle here, take an old baffle from there, enlarge this area and decrease that. When the work is completed the plant is started up. The engineer looks at the figures on the paper, then at the draft gage, then he swears. Maybe he forgot about the unburned carbon.

Fitting Piston Rings

Rings fitted as a true circle must be returned after cutting, and one engineer found this jig helpful and convenient.

By EARL PAGETT

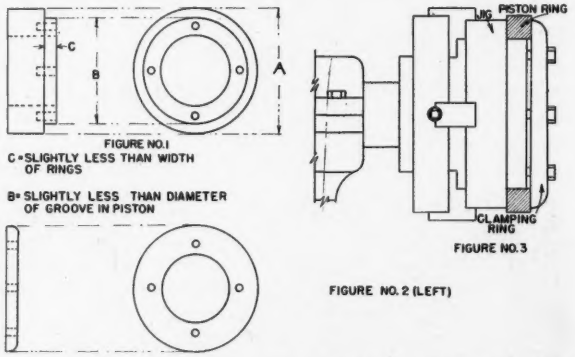
WHEN a new set of piston rings for a gas or Diesel engine cylinder, either of two methods may be used. The rings may be made of the proper width and thickness to fit the groove properly, but with a diameter in excess of cylinder diameter so as to give the proper spring, after a piece is cut out to give the right end clearance when contracted and forced into the cylinder.

With the piece cut out, and the ring contracted to the cylinder diameter, the ring will not be a true circle and cannot fit the cylinder accurately. True it will not miss an accurate fit very far, and wears to a good fit in due time, so some engineers use this method.

In the second method the ring is re-turned on the outer diameter to the actual cylinder diameter, which it will assume when placed in the cylinder. This makes the ring a true circle and gives an accurate fit with the cylinder wall at all points of its circumference.

Re-turning of the ring will, however, require a jig. There are several ways of making this, but a simple form is shown in Figs. 1, 2 and 3. This jig will need to be made special for the ring size to be turned. If several sizes of ring are used in the plant a jig will be needed for each size. Figure 1 is the jig, Fig. 2 the clamping ring and Fig. 3 the jig, a cross section of the ring and the clamping ring assembled and centered up in the lathe chuck ready for turning.

Dimension A of Fig. 1 should be at least 1/16 in. less than the diameter of the cylinder. To prevent the ring



Figs. 1 to 3. Jig, clamping ring and complete assembly in lathe chuck ready for turning piston rings to true cylinder diameter. A should be cylinder diameter minus 1/16 in., B, slightly less than the diameter of the bottom of the groove in the piston and C slightly less than the width of the ring or rings to be turned

gripping, Dimension B must be of larger diameter than the bottom of the ring groove in the piston, and considerably larger, if the ring groove in the piston is much deeper than the thickness of the ring. Dimension C will need to be slightly less than the width of the ring to be turned if the jig is made for a single ring, or slightly less than the combined width of several rings, if all are to be turned at one operation.

While it may take slightly longer, the single ring jig is easier to use, due to the difficulty in getting several rings clamped in the proper position. Assuming that the rings have been made of the proper dimensions, except 1/16 in. has been left on the circumference for re-turning, the jig is centered up in the lathe chuck. The clamping ring may be removed and the ring placed on the jig, or the clamping bolts loosened slightly and the ring sprung on over.

When the ring is in place, the clamping ring is tightened slightly and the ring driven to place with a soft hammer. When in the proper position, the ring will touch the jig all around on dimension B and the ends will be apart the proper clearance for expansion when in the cylinder, usually about 0.006 in. for each inch diameter of the cylinder. The ring may now be turned to exact cylinder diameter on its circumference, and will then fit the cylinder accurately if the cylinder has not been worn out of true.

Rings made in this way will make a good tight piston from the first and no anxiety need be felt as to whether they are going to have proper room for expansion or grip the bottom of the ring groove in the piston and be too tight in the cylinder.

Wear in Turbine Parts

Corrosion and mechanical action usually combine to cause impairment of parts.[1]

By N. L. MOCHEL
Westinghouse Elec. & Mfg. Co.

AMONG THE MANY meanings which one finds in the dictionary for the word *wear* is "impairment by use," or "loss by the service, exposure, decay or injury incident to ordinary use." This interpretation suggests more than mere displacement of material as the result of physical contact and is especially useful in discussing wear from the viewpoint of power equipment. In many cases, the impairment by use is certainly due to more than a single influence. For example, there are many cases where corrosion and mechanical or physical action are obviously present together and are jointly responsible for the impairment experienced. It is believed that inability to appreciate such joint action, or failure to determine and treat with the predominant influence, may at times have delayed the solution of some wear problems.

In the power-equipment field, one encounters two general situations, which are often quite opposed to each other. Power equipment makes use of many moving metal parts. Both moving and fixed metal parts are not only often in contact with each other, but invariably subject to the action of a variety of non-metallic materials in solid, liquid and gaseous form. Some of these materials are abrasive, while others are quite corrosive. Water conditions, the nature of the steam, and the nature of fuels vary greatly throughout the country. Operating conditions will differ in many ways.

Opposed to this situation is that which confronts the turbine builder especially, although it applies to other power equipment as well. There are few lines of development in which the product must operate under such varying conditions, under such high temperature influences, at such high rotative speeds, under conditions of close clearances, often in contact without means for lubrication, with such minimum tolerated outage from service, and where the expected useful life is so great, as is the case with the modern steam turbine; and in some degree, other types of power equipment.

Under such general conditions, one may naturally expect that impairment in use, or loss incident to ordinary use, may often be the result of two or more influences. In the following, the author deals with a few cases of wear in such equipment, the nature of the wear, and the means taken to overcome such action.

[1]From a paper "Wear From the Power Equipment Viewpoint" presented before the A. S. T. M. Symposium on Wear.

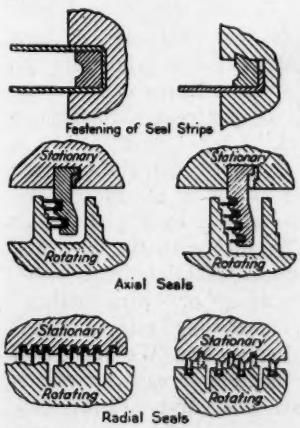


Fig. 1. Sealing details for glands and dummies (Left)

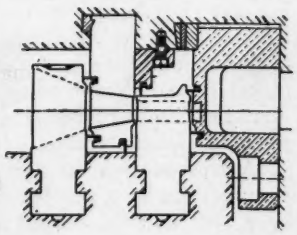


Fig. 2. Impulse stage with sealing strips (Above)

The Modern Steam Turbine

A number of turbines are being built for operating under inlet steam conditions of 1200 lb. and up to 959 deg. F. Reference will be made to some of the blades; the seal strips at dummies, glands, and blades; the valves and seats; the valve lift rods and the throttle valve stems.

Occasionally, wear has been experienced on the edges of the impulse or Curtis blades. Wet steam conditions or the presence of objectionable types and amounts of solids in the steam have invariably been the cause, but such action is not often encountered today.

At the exhaust end of complete-expansion turbines or of low-pressure turbines (usually on the last row or rows of blades only, although on very large units it may be the last two or even three rows) there is a very serious wear problem.[2] For years, this action was considered to be largely a corrosive condition. Attempts to overcome the condition from that approach met with failure, and laboratory studies from that viewpoint failed to duplicate the action. Today, we recognize the action as almost entirely a physical one, influenced to some degree by corrosion. Truly, the term *wear* better represents the action than any other.

Wear is at the back of the inlet edge of the blade, and over a very restricted area. It is due to the fact that the steam at this point in the turbine carries large amounts of water particles, which travel more slowly than the steam and strike the rapidly moving blades at those area where action is noted. This wear was first observed when tip speeds began to exceed approximately 900 ft. per sec. The blades in the last row of large turbine have a tip speed of 1256 ft. per sec.

[2]See Turbine Blade Erosion, Power Plant Engineering, page 108 and 121, March, 1938.

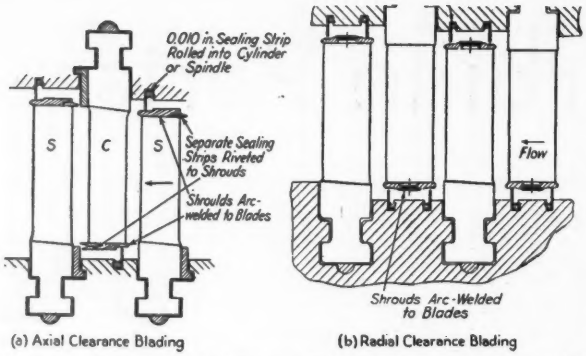


Fig. 3. Reaction blading and sealing strips for axial and radial clearance

There have been two obvious approaches to a solution of this problem. The first has been to get rid of the moisture so far as is possible.[3] Moisture catchers have been provided to drain off the water in advance of the last rows of blades. The second is a metallurgical approach, to provide materials that will resist the wear. Briefly, we know of no material that will satisfactorily resist the wear and which is otherwise satisfactory for such turbine blades. However, the blades can be produced of otherwise satisfactory material, and shields of a suitably resistant material can be attached to the blades at those areas where the action takes place. This arrangement offers the additional advantage of making it possible to renew the protective shields, when they eventually wear to an undesirable degree.

Originally flat strips were used, but later the strips were so fashioned as to lap over the edge of the inlet edge and further protect this point. Such strips are secured by silver soldering.

One European builder has used shields of 18 per cent tungsten steel and has secured acceptable resistance. The Westinghouse Co. has examined many materials for this purpose and has concluded that the most useful material now known is No. 6 Stellite, of a composition as follows: Cobalt, per cent, min., 55; chromium, per cent, 27 to 33; tungsten, per cent, 3 to 6; other elements, per cent, max., 7.5. The material can be produced in the desired formed strips, it is readily silver soldered, it maintains its hardness during silver soldering and in service, and gives marked resistance to the erosive action.

An erosion testing machine has given excellent service in predicting the life of shield and blade materials in service. It has rated materials in exactly the same order as actual service and the action is produced in but a few minutes. Two speciments, placed opposite each other in the disk, are revolved at very high speeds and pass through fine water sprays at two points in each revolution.

Sealing Strips

Sealing strips and sections for dummies and glands in turbines were for many years made from 70-30 or 72-28 brass. This material has been an excellent one for the purpose, and is still used in older machines and where temperatures are low. It has excellent "rubbing" characteristics when contact is made with the rotating shaft or the stationary cylinder, depending upon which member carries the sealing strips.

But as temperatures advanced to 750 deg. F., then to 850 deg. F., and now to 925 deg. to 950 deg. F. the brass material was no longer suitable for the purpose. Pure nickel and copper-nickel-iron alloys were first used but were not entirely satisfactory.

Laboratory tests of many materials finally developed a low-carbon 13 per cent chromium steel containing 0.5 per cent molybdenum as the best rubbing material with the otherwise necessary characteristics, such as strength at high temperatures, oxidation and corrosion resistance, thermal expansion close to that of ordinary steel, and ability to be formed into desired shapes.

Laboratory tests on material for these purposes were made at two stages in the development. Strips were brought into contact with a rotating disk under operating conditions as regards temperatures and speeds. Disks were made of the actual turbine rotor material. With this material, C. R. Soderberg developed a very efficient type of seal, using thin strips 0.010 to 0.020 in. thick. The material can be flanged and the edge bent as desired. Figure 1 shows the application of such strips for dummy and gland sealing, Fig. 2 for Curtis blades, and Fig. 3 for reaction blades.

Valves and Valve Seats

Axial sealing strips are "ground-in" to a uniform seating in first setting up the turbine, while rotating the rotor. Contact of any sealing strips with rotor or cylinder or blade shrouds may take place during operation of the turbine, due to expansion of the various parts and slight movements of the cylinder or the rotor. These conditions immediately present a definite wear problem. Usually, rapid wear of parts is not desired. However, in this case, when contact occurs, rapidity of wear is quite necessary. The material must wear or "mushroom" quickly, giving rise to as little local heat as possible; there must be no tendency to "pick up" or seize or unduly score or wear the main element, be it rotor, cylinder or blade shroud. The above-mentioned material has rendered excellent service in this respect. The service rendered by this material is even more interesting if one considers the variety of materials that are used in contact with it. Invariably, any wear problem must consider two materials that act upon each other. In the case of these sealing strips, they are actually used in combination with the following materials: cast iron, cast carbon steel, cast carbon-molybdenum steel, forged 0.40 per cent carbon steel, forged nickel steel, forged nickel-molybdenum or nickel-chromium-molybdenum steel, 12 per cent chromium steel, and arc-deposited 18 per cent chromium, 8 per cent nickel stainless steel.

A cross-section through a steam chest, showing the arrangement of a number of valves of the mushroom-head type and valve seats are shown by Fig. 4. Wear of the valve at its point of contact with the seat may occur if a proper combination of materials is not used. Long ago, the term "wire-drawing" or "wire-cutting" was applied to this action. The author believes that it is a combination of wear and corrosion. We know that this action occurred in one particular case by reason of very wet steam conditions. The valve was nitrided,

[3] See Draining Moisture from Turbines, Power Plant Engineering, page 970, Oct. 1, 1931.

with a Vickers hardness of over 900. The valve seat was low-carbon 13 per cent chromium steel, Brinell hardness 210. The nitrided surface was not sufficiently resistant to corrosion, and very slight surface corrosion permitted the passage of a fine leak of steam. The products of corrosion were rapidly carried away. High-pressure wet steam passing through a small space has intense wearing action on most materials. In this case, once the wear had penetrated through the nitrided case, action became more rapid.

Under such wet-steam conditions, we know that age-hardened aluminum-monel metal resists this action. Heat-treated high-carbon-high-chromium steel, having 1.70 per cent carbon and 18 per cent chromium, with a Rockwell hardness "C" scale of 43 is now largely used for these valves and gives excellent service. The valve seat of low-carbon 13 per cent chromium steel is sometimes stellited at the point of contact.

Lift Rods and Valve Stems

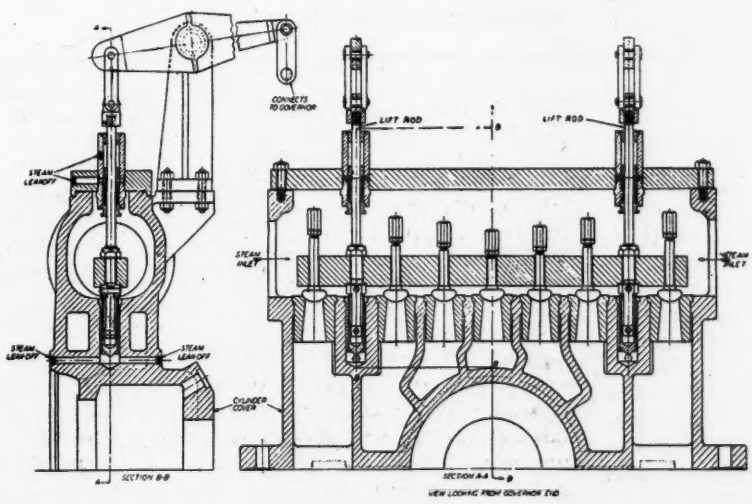
In Fig. 4, it will be noted that the bar carrying the seven valves is raised and lowered by means of two lift rods, and that these pass through guide bushings, located in a holder, in the steam chest cover plate.

Figure 5 shows the cross-section of a throttle valve of a new inverted type. The valve seat in these larger throttle valves is usually a forging of carbon-molybdenum steel with the contact surface stellited. It will be noted that the stem is guided through two bushings where it passes through the wall of the body.

In each case, the guide bushings must serve as steam seals as well as guides. A wear and seizure problem is readily recognized. Temperatures of steam run as high as 950 deg. F. and pressures up to 1200 lb. Lubrication of the surfaces, as we usually know lubrication, is out of the question.

Use of nitrided steel bushings with stems of either 20 per cent nickel, 7 per cent chromium steel or low-carbon, 12 per cent chromium steel gave satisfactory service for years, but higher temperatures forced the development of new combinations.

In older designs, with the valve closed, the stem was invariably exposed to the high-temperature steam. Upon opening the valve, a hot and therefore somewhat enlarged stem, from thermal expansion, had to be drawn upward through a somewhat colder guide bushing, and galling, wear and seizure sometimes occurred. In the new inverted design, it will be noted the opposite conditions exist. Again in this matter, laboratory tests have shown the way and an exceedingly large number of materials for stems and bushings have been tested. Circular grooves are quite beneficial where wear and seizure problems are involved to break the continuity of surface and to provide a place of deposit for the products of wear. One specimen, which was operated through a bushing made up of laminated sheet metal with graphite between the laminations, came through the test with an excellent appearance. The side load was 50 lb. Another specimen was operated under the same conditions for 46 hr. at 150 lb. side load, with excellent results. To determine the value of the graphite as a lubricant at this temperature (800 deg. F.) two more tests were made with loads of 50 and 150 lb. but with no graphite. Some seizure occurred with the heavier load, and more wear took place with the lighter load; obviously, graphite has a real value.



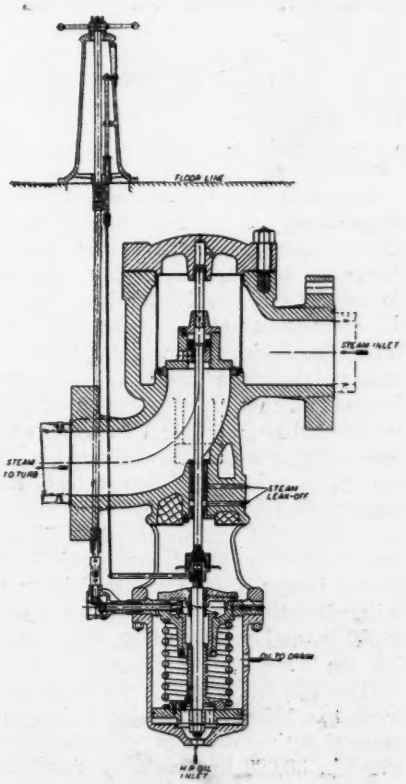


Fig. 4. (Above) Section through steam chest of turbine

Fig. 5. (Right) New type of throttle valve designed to eliminate stem wear and seizure

MODERN UTILITY

II—Planning for, and Carrying out of, a Program To Provide Adequate Generating Facilities on the Extensive Integrated American Gas and Electric Service Corporation System

By
Philip Sporn
Vice President and Chief Engineer
American Gas & Electric Service Corp.
New York, N. Y.

Part II. The first installment of the article discussed the system as a whole and the Appalachian Electric Power Group in particular, ending with a description of Logan Station. This installment takes up the Ohio Power Co. group with Windsor Station, the Indiana & Michigan Electric Co. group with Twin Branch Station, and ends with general conclusions regarding present day trends.

EXTENDING over portions of the seven states of Tennessee, Virginia, Kentucky, West Virginia, Ohio, Indiana, and Michigan, the system of the American Gas and Electric is unusually extensive, integrated, fully coordinated and interconnected with adjacent systems at strategic points. It is divided into three major groups. Planning for, and providing adequate generating facilities must of necessity involve the determination of long time load trends, a detailed consideration of the system as a whole and the needs of the individual units so as to make each self-sustaining. The eastern group and Logan station were described earlier; the remaining two groups with Windsor and Twin Branch Station are discussed below.

VI. Generation Program of the Ohio Power System

The Ohio Power Co. system, which also includes (because it supplies the major requirements and its facilities are operated in coordination with those of the Ohio Power Co.) the requirements of the Wheeling Electric Co., serves an extensive territory extending over almost the entire state of Ohio and the area in and around Wheeling. This is shown clearly in Fig. 3. Although small plants are located at Lima, Fremont, Newark and Portsmouth, the primary plants of the Ohio Power Co. are located at Windsor (W. Va.), and at Philo, Ohio. The latter, still a modern plant, has a capacity of 245,000 kw., consisting of two 40,000, and one cross-compound 165,000 kw. units. The latter is made up of one 53,000 high pressure and two 53,000 kw. low pressure units with direct connected 3,000 kw. house turbines. It was installed in 1927 but was not completely boilered until 1932. The pressure of the entire plant is 600 lb. and the operating temperature approximately 720 deg. F.

The Windsor plant on the other hand was originally erected in 1916 and extended to its present size in 1922. Since that time it has been operating as a six-unit plant with six 30,000 kw. turbines, four of 250 lb. and two of 325 lb. throttle pressure, both at a steam temperature of approximately 625 deg. F. This is a jointly owned plant, three units belonging to the Ohio Power Co. and the other three (including the two later vintage units) to the West Penn Power Co., but is operated as a single plant for best overall economy. However, it will be observed that the plant has at the present time an effective life of close to 20 yr.

Windsor

Originally the output of the Ohio portion of the plant was utilized partly in the Wheeling area and in the area north of Wheeling centering around Steubenville, Ohio, but the major portion was transmitted to other parts of that state, principally to Canton and the surrounding territory. With the growth of load in the Ohio River valley, north and south of Windsor, a greater percentage of the output was utilized in the immediate vicinity of the plant. Keeping in mind the general principles already discussed as to the relationship between transmission and generation and the effect of the cost of one on the economics of the other, and the fact that operating mounting costs due to rising maintenance and heavy man-hour requirements per unit output at Windsor[2] called for modernization it was

natural that when additional capacity was needed on the system that the decision was made to superpose there.

Superposition will be accomplished by the installation of two 750,000 lb. per hr. boilers feeding a 60,000 kw., 3600 r.p.m. back-pressure generator which will exhaust and supply the steam for three of the existing low pressure units. This obviously takes care of modernization and superposition of one-half of the station. The West Penn half of the station will be modernized by a substantially similar program consisting of a duplicate turbine which has already been purchased, supplied with steam by boilers of the same pressure and temperature, but of size and rating not as yet determined. A summation of the principal items of equipment, both in the existing and in the extended and superposed plant, is shown in Table II.

Boilers Different

One of the outstanding features of the two boilers is that although they will be of substantially similar physical dimensions, they will not be of the same manufacture, nor even of the same type. One of them, shown in Fig. 8, is a three drum so-called VS-3 type Combustion Engineering Co. unit employing tangential firing, a steeper than normal angle for the bent-tube vertical sections, convection type superheaters and standard arrangement of economizers and Ljungstrom air heaters. Outstanding features are auxiliary burners firing horizontally into the upper part of the furnace to provide, with damper by-pass, superheat control over a wider range that is possible by by-passing alone.

The second, shown in Figs. 9 and 10, is a Foster Wheeler boiler, using a twin furnace arrangement with a limited straight tube section. One furnace is completely water-cooled and the other is cooled by a combination of radiant superheat and water-walls. Water cooling, as is the case with the Combustion boiler shown in Fig. 8, is of the tangent tube to tube construction. Both furnaces discharge through a small section of convection steam generating surface, a convection superheater of the pendent loop type, an economizer and a Ljungstrom air preheater.

Superheat control over an extremely wide range is obtained by differentially firing the two furnaces without the use of auxiliary burners or by-pass. Flexibility and range of control are facilitated by the use of two exhausters for each mill, each exhauster serving one burner

[2]For a tabulation of the principal data on Logan, Windsor and Twin Branch see Power Plant Engineering p. 721, Dec., 1937.

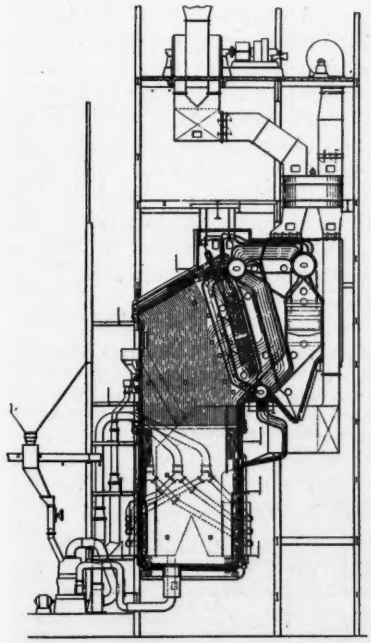


Fig. 8. One of the two 750,000 lb. per hr., 1475 lb. steam generators at the Windsor Plant of The Ohio Power Co. This Combustion Engineering Co. boiler will be of the VS-3 wet bottom type tangentially fired. A wide range of superheat control is obtained by auxiliary burners firing horizontally into the upper part of the furnace

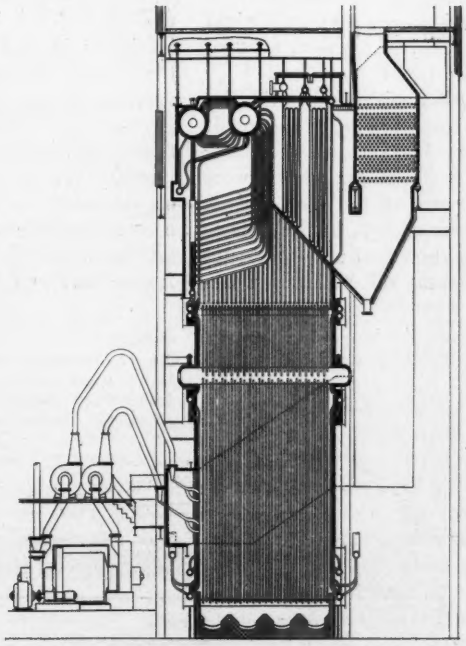


Fig. 9. The Foster Wheeler 750,000 lb. per hr. steam generator at Windsor will be similar externally and of about the same physical dimensions as the other boiler shown in Fig. 8. This unit is of the twin furnace type. A cross section of this boiler at right angles to this section, and, parallel with the steam drum is shown by Fig. 10

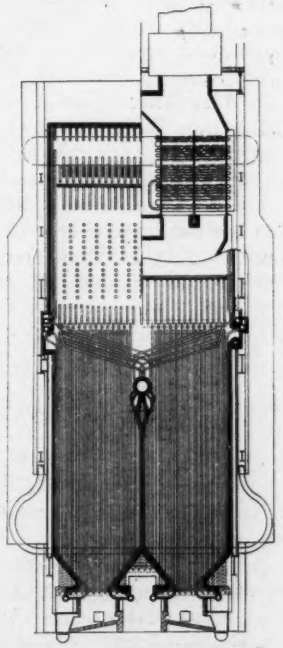


Fig. 10. Superheat control in the Windsor Foster Wheeler boiler is obtained by differentially firing the two furnaces without the use of dampers or by-passes. The two boilers, one a dry bottom type and one a wet bottom type, will give an unusually wide range of superheat control and allow for a broad and flexible range in plant loading

nesses of the wet bottom boiler always appear when an attempt is made to go below a limited percentage of full rating, generally well in excess of 50 per cent. Thus it was felt that the combination chosen will give the utmost flexibility for the station and permit not only maximum freedom from slag, but ability to take

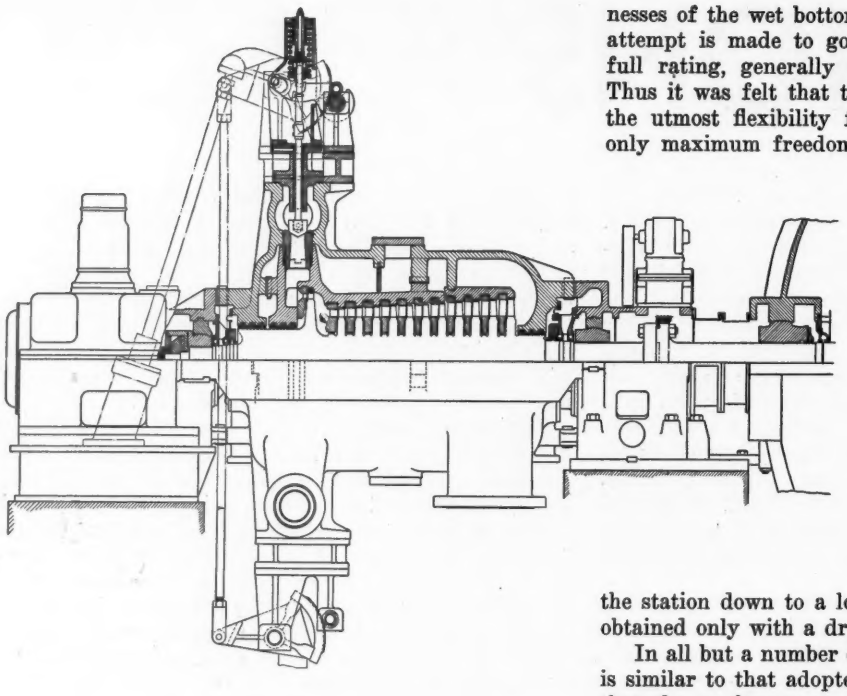


Fig. 11. Section through the 60,000 kw., 1250 lb., 12-stag, 3600 r.p.m. turbine to be installed at Windsor. This unit is similar to the Logan unit, except, for the additional stage, slightly higher back-pressure and with the throttle valve definitely anchored to the turbine foundation

in each furnace. The net effect of this is to give maximum ease of control of superheat over the entire range and within the limits designed, and a larger than normal amount of radiant heat absorbing surface. This facilitates the problem of keeping the upper regions of the boiler from slagging, and made possible the development of the design for dry bottom operation even under the rigid operating specification of ash fusion temperatures of coal running from 1900 to 2700 deg. F.

A striking thing in connection with this entire installation is the use of two boilers to supply the plant output, one of which has a dry bottom and the other a wet bottom. The reasons for this arrangement were not only the inherent adaptations of the two designs to the particuluar type of bottom chosen, but a definite realization that the inherent weaknesses of any dry boiler are at the topmost ratings, whereas the inherent weakthe station down to a low rating that can generally be obtained only with a dry bottom furnace.

In all but a number of minor respects, the heat cycle is similar to that adopted for Logan, but it is expected that the performance at full load will be better than at Logan, due principally to the better Rankine efficiency of the Windsor low pressure units and the more efficient low pressure cycle. The turbine will be a 12-stage unit as against 11 stages at Logan, but as at Logan, will have a throttle pressure of 1250 lb. and a throttle temperature of 925 deg. F. It will exhaust against a back-pressure of 235 lb. ga. A cross-section of the turbine is shown in Fig. 11. As at Logan, the unit employs the double casing construction, but here the throttle valve is definitely anchored to the turbine foundation.

As contrasted with the Logan unit, in which the distributing valves were all located below the turbine floor line, the Windsor turbine has valve in head construction considerably simplifying the piping problem both from a construction and from an operating standpoint. The generator itself is substantially similar to that at Logan and will be hydrogen-cooled except that it will

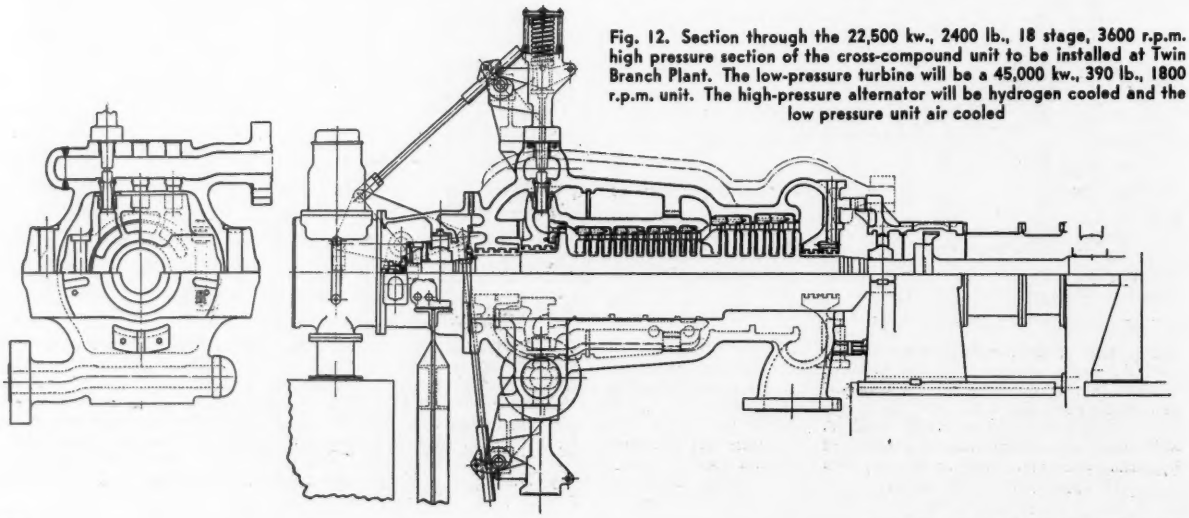


Fig. 12. Section through the 22,500 kw., 2400 lb., 18 stage, 3600 r.p.m. high pressure section of the cross-compound unit to be installed at Twin Branch Plant. The low-pressure turbine will be a 45,000 kw., 390 lb., 1800 r.p.m. unit. The high-pressure alternator will be hydrogen cooled and the low pressure unit air cooled

employ the conventional stator construction and utilize four banks of fin-type coolers located within the stator for that purpose. The exciter will be geared as at Logan but will only be used to supply the excitation of the high pressure machine, as individual excitation for the low pressure machines will be supplied by the present direct-connected exciters.

An outstanding feature of the turbine installation will be the substantial automatic and supervistory control for starting and stopping of the unit. Dual control will permit push-button operation from the main control room or from the turbine switchboard located adjacent to the turbine. Complete manual control of the unit is available from the turbine room only. In starting, the control is automatic up to the time the machine is brought to rated speed and synchronized to the bus. Once the machine is synchronized, the automatic control features are cut out and the unit is placed on manual control. When it is desired to shut down the unit, the automatic equipment is again cut into service to insure the proper sequence of valve operation.

While the automatic operation involves motorizing of all steam, water, and oil valves in connection with the turbines, developments that really make the scheme feasible are the vibration and shaft eccentricity recorders. It is these measurements that make possible the bringing of the turbine from rest to full speed in the shortest possible time consistent with satisfactory limits of vibration and shaft eccentricity. It is believed that with dependable measurements or vibration and shaft eccentricity, a steam turbine can be brought up to speed automatically with far less disturbance to the machine than can be done by manual means. While the automatic feature is normally cut out once the machine is brought up to speed and not used again until ready to shut down the unit, the vibration and shaft eccentricity recorders do give a continuous visual indication of these quantities and also an audible indication if certain limits are exceeded.

This turbine and boiler installation is now in the process of active construction and it is expected that the unit will begin trial operation around November 1, 1938. This program of expansion at Windsor will complete, for some time to come, the development at that point. Further increments of capacity will be taken care of either by the installation of additional capacity at Philo[3] or by the development of a new generating source. It is obvious from the discussions already given that, under normal conditions, the economics would be preponderantly in favor of Philo. This, however. may be modified to a considerable extent by future develop-

Table II. Summary of Existing and New Equipment at Windsor Steam Plant. For a tabulation of principal data on this station on Twin Branch shown by Table II and Logan shown by Table I of the last issue, see POWER PLANT ENGINEERING, p. 721, December, 1937

EXISTING PLANT	PLANT EXTENSION
BOILER PLANT	
6—B. & W. 1409 hp. standard boilers (approximately — 140,000 lb. per hr. each) and 2—B. & W. 503 hp. reheat boilers. 3 standard and 1 reheat boiler equipped with Coxe chain grate stokers and 3 standard and 1 reheat boilers equipped with B. & W. chain grate stokers. Each boiler equipped with I. D. and F. D. fans. Economizers and air heaters are used. Steam pressure 650 lb. gauge — Total temperature 748 deg. F.	1—B. & W. 550,000 lb. per hr. wet bottom steam generator with reheat section and with economizer and Ljungstrom air heaters. Boiler is fired by a pulverized coal unit system consisting of 3 B. & W. mills, 2—duplex I.D. and F.D. fans will be used. Boiler operates at 2400 lb. and 940° F.
TURBINE PLANT	
2—42,000 kw. 1800 r.p.m. 17 stage units with surface condensers and bled at 6th, 8th, 12th and 16th stages for feedwater heating. Steam is extracted from the 7th stage and returned to the 8th stage after reheating. Total existing capacity 84,000 kw.	G.E. 67,500 kw cross compound unit consisting of a 22,500 kw. 18 stage high pressure and a 45,000 kw. 17 stage 1800 r.p.m. low pressure unit. 22,500 kw. generator hydrogen cooled. 45,000 kw. generator air cooled. Exhaust steam from high pressure unit is reheated to about 850° F. minimum before entering the low pressure unit. New capacity added 67,500 kw. Total plant capacity will be 151,500 kw.
FEED HEAT CYCLE	
	Feedwater is reheated to a final temperature of about 458 deg. F. by means of 5 stages of actual regenerative heating. One of the heaters will be of the deaeration type. An evaporator is used with bleed from the 11th stage of the low pressure unit. 3 sets Ingersoll-Rand primary and secondary feed pumps will be used. Each set will be turbine driven.
POWER TRANSFORMERS	
2—45,000 kv-a. 11/132 kv. transformers.	Westinghouse 70,000 kv-a. 11/27/132 kv. 3-winding bank.

Table III. Summary of Existing and New Equipment at Twin Branch Steam Plant

EXISTING PLANT	PLANT EXTENSION
BOILER PLANT	
12—B. & W. 1262.5 hp. (approximately 100,000 lb. per hr. each). 10 equipped with Westinghouse under feed stokers and 2 with B. & W. chain grate stokers. (3 boilers being removed to make room for new high pressure boilers). Each boiler equipped with I.D. and F.D. fans. Economizers are used. No air preheaters. Steam pressure 235 lb. gauge—Total temperature 525 deg. F.	1—Foster-Wheeler 750,000 lb. per hr. dry bottom steam generator with economizers and Ljungstrom air preheater. Boiler is fired by a pulverized coal unit system consisting of 3 Hardinge mills, each having a capacity of 15 tons per hr. 1—Combustion Engineering Co. 750,000 lb. per hr. wet bottom steam generator with economizers and Ljungstrom air preheaters. Boiler is fired by a pulverized coal unit system consisting of 3 Raymond bowl mills, each having a capacity of 15 tons per hr. Boilers operate at 1350 lb. and 925 deg. F.
TURBINE PLANT	
3—G.E. 30,000 kw. 1800 r.p.m. units with surface condensers and bled at 5th, 11th and 13th stages for feedwater heating. Total existing capacity, 90,000 kw. (The Ohio Power Co. section); capacity of entire plant 180,000 kw.	1—G.E. 60,000 kv. 12-stage 3600 r.p.m. superposition unit with hydrogen cooled generator; exhausts at 225 lb. into the existing system of low pressure turbines (3-30,000 kw. units). New capacity added 60,000 kw. Total capacity 150,000 kw. (The Ohio Pr. Co. section.)
FEED HEAT CYCLE	
	Feedwater is heated to a final temperature of 395° F. with steam bled from the 13th stage of the 3-30,000 kw. low pressure units, with exhaust steam from the turbine driven auxiliaries and with 235 lb. steam from the high pressure turbine exhaust. In addition to the necessary heaters a deaerating heater (Elliott) and evaporator were added to the cycle. 4—Boiler feed pumps. 2—Worthington (turbine driven); 2—Ingersoll Rand (one turbine driven and one motor driven).
POWER TRANSFORMERS	
The Ohio Power section—3-30,000 kv-a. 11/66 kv. banks 2—50,000 kv-a. 11/132 kv.	G.E.—70,000 kv-a. 11/66/132 kv. bank.

[3]For a description of Philo see POWER PLANT ENGINEERING, p. 570, June 1, 1925.

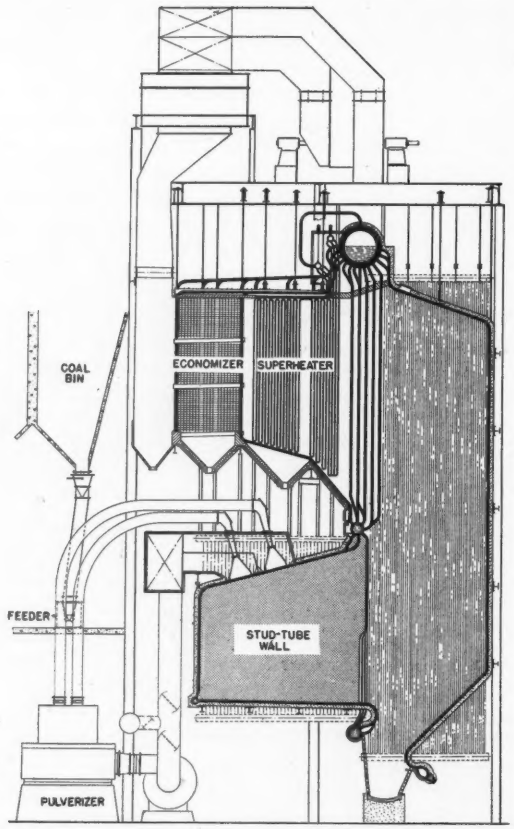


Fig. 13. Section of the 550,000 lb. per hr., 2400 lb. Babcock & Wilcox steam generator which will be installed at Twin Branch Plant. (Some minor changes may be made in final design)

ments in the way of loading of existing transmission facilities on the system.

VII. Generation Program of the Indiana & Michigan Electric System

The Indiana & Michigan Electric Co. serves a combined industrial and residential load through the upper half of Indiana and through the southwest section of Michigan. Its location with regard to the rest of the system is shown on the system diagram Fig. 3. The peak load of this company, including the load of the Indiana General Service Co., substantially all of whose requirements it furnishes, was approximately 145,000 kw. before the recent recession in load. At the present time the load is furnished from the Twin Branch[4] 650 lb. steam plant with a capacity of 84,000 kw.; by some 22,000 kw. of hydro capacity; and by purchase from interconnections both within and outside of the system of which this company is a part.

Possibilities of strengthening, that is, adding to the transmission system were thoroughly studied, but these were finally abandoned. These studies had shown again what is well known to those who have studied the problem in the past, namely: that where fuel sources can generally be reached by rail, long distance transmission is not a paying proposition; that even at 70 per cent load factor, the maximum distance that power can be transmitted electrically, on the same economic basis that coal can be transmitted by freight, is still only about 100 mi.; and this distance decreases as the load factor decreases. The problem was thus reduced to one that called for generation or purchase of the required capacity. The latter was considered but in the light of the fact that a good deal of so-called framework of a power plant was already in existence at Twin Branch, it was found that capacity could be added more economically on that system than on any available neighboring system.

Having reduced it to that point, superposition was turned down; first, because of the age of the plant, which is still comparatively young; second, because more capacity was needed than could be economically superposed over an 84,000 kw., 650 lb. plant, and third, because the load factor to justify superposition, even if everything else was satisfactory, was higher than could be obtained without sacrifice of other economies possible through the interconnected system. This, therefore, meant a straight condensing unit. The size of the unit chosen was such that it is expected that at the time it comes on the system it will be possible for it to occupy an almost complete base location on the load curve without sacrificing materially the position of the present units while still taking full advantage of the limited amount of hydro.

Twin Branch

This analysis resulted in the selection of a 67,500 kw., 2400 lb., 940 deg. F. unit. The pressure of 2400 lb. was selected; first, because this was the limiting boiler pressure that could be adopted without resorting to forced circulation; second, 2400 lb. did not appear to offer any insurmountable difficulties either on the turbine or on the boiler feed pumps; third, this pressure definitely offered attractive future possibilities in the way of superposition on the present 650 lb. plants at Twin Branch[2] and possibly at other locations; fourth, the economy both in capital and operating costs that the 2400 lb. cycle offered is particularly attractive at Twin Branch. This is an expensive fuel point on the interconnected system, coal costs running to approximately 17½ ct. per million B.t.u., for example, as against 8 ct. at Philo and approximately 5.2 ct. at Logan. Finally, for the size chosen the load factor that will be available to the unit is particularly high, and further improves the economies of the more efficient setup.

A General Electric two element turbine will be installed with the high pressure element rated at 22,500 kw., 2300 lb. throttle pressure at a temperature of 940 deg. F., and an exhaust pressure of 400 lb. absolute. This is an 18 stage unit with provision for two stages of bleeding. A cross-section is shown by Fig. 12 and a comparison with Fig. 11 will show its similarity to the Windsor unit which in turn is quite similar to Logan. Like these units it employs the double-jacketed construction but has the additional stages. Again like the other machines it will operate at 3600 r.p.m. and the generator will be hydrogen-cooled.

On the low pressure turbine, a 17 stage, 45,000 kw. unit operating at 1800 r.p.m., the normal throttle pressure will be 390 lb. abs. and the normal temperature 900 deg. F. The low pressure alternator will be one of

[4]For a description of the 650 lb. Twin Branch Station see Power Plant Engineering, p. 118, Jan. 15, 1926.

the standard designs that have been developed for 1800 r.p.m. operation, air cooled on a closed air system. The Ingersoll-Rand boiler feed pumps, of which there will be three, will be turbine-driven to obtain variable speeds up to 4000 r.p.m. and will be of the barrel type. Here turbine drive was selected because of the ease in getting variable speed, and the possibility of operating at a more efficient pump speed than motor drive would have made possible without resorting to complicated gearing.

The Babcock & Wilcox boiler will be almost entirely radiant surface, the only convection surface in the boiler proper being two narrow sections between the secondary furnace and the superheater and between the superheater and economizer section. Figure 13 is a cross-section of the boiler so far as it is known at the present time, for it is subject to minor modifications as the problem of proper balance between water wall and reheater surface (which is also part of the secondary furnace), is worked out. An examination of Fig. 13 will show a comparative simplicity of gas flow paths, the lack of complication in tube shapes, and the minimum resort to turns and bends. The latter is particularly important at 2400 lb., where resistance to flow must be kept to a minimum in view of the fact that there is so little hydraulic head to spare.

A straight regenerative-reheat cycle will be used, and the flow diagram, although subject to minor changes, will be substantially as shown in Fig. 14. The outstanding features are the direct line simple flow characteristics typical of the Logan and Windsor cycles and the utilization of a cross-over pressure around 400 lb. Substantially the same pressure as that utilized at the Deepwater, N. J., plant. The variable cross-over pressure gives a much flatter efficiency characteristic than is possible with a fixed cross-over at pressure. The use of turbines for boiler feed pump drive has already been discussed, and it will be noted, it is planned to drive the tank pumps from the main boiler feed pump turbine.

Neither the forced or induced draft fans at Twin Branch will be turbine driven because of the simplicity of the boiler gas passages has reduced the forced and induced draft fan power to such a degree that variable drive can be obtained more economically by electric than by turbine drive. The expected performance has not been indicated on the flow diagram but at full rating it is expected that the performance will be some 12½ per cent better than Windsor. It needs to be pointed out, however, that such a comparison is not always possible on an equivalent basis because of the differences in coals which not only affects the method of figuring boiler heat balance, but which, due to the higher sulphur content of the Twin Branch coal, precludes stack temperatures as low as might be possible with a coal of lower sulphur content.

A summary of this addition covering boiler, turbine and condenser plants, transformers and total generating capacity before and after the extension, is given in Table III. This program of expansion, it is expected will be completed late in 1939 or the early part of 1940. Its completion will bring the installed capacity of the Indiana & Michigan system up to the point where, with the proper use of the existing facilities, it will be able to supply its requirements possibly for 2 yr. beyond the completion date. The next step will involve obtaining of additional capacity from surrounding systems or additional increments of generation at Twin Branch. This latter may be by further straight condensing units or by a limited amount of superposition. The condition of the transmission system with respect to the load and growth of the system at that time will have a major influence on the choice.

VIII. The Problem of Providing Adequate Facilities on Smaller Integrated Systems

On the American Gas & Electric Co. system there are two smaller fully integrated and co-ordinated groups, one in the southern section of New Jersey with a peak of approximately 70,000 kw., the other in the Lackawanna Valley, centering in and around Scranton, Penn., with a peak of approximately 60,000 kw. On

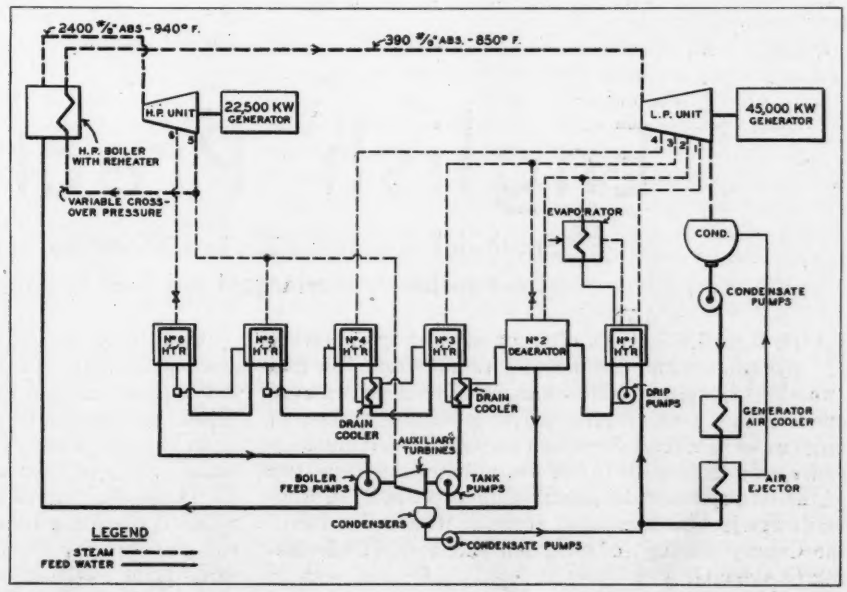


Fig. 14. Heat flow diagram for the Twin Branch Plant which is still subject to minor changes

both of these systems the problem of providing adequate generating facilities has come to the fore within the past year. The former of these two groups has one of the most modern generating stations at Deepwater,[5] New Jersey, operating at 1200 lb., and a less modern station operating within the city limits of Atlantic City. The latter of these two groups again has a modern generating station at West Pittston known as the Stanton Station[6] and a less modern station within the limits of Scranton, known as the Suburban Plant. How the problem of providing adequate facilities in each of these cases is being solved is interesting but is perhaps beyond the scope of the present article. The principles employed, of course, are the same as those outlined with regard to the three systems described. It may be, and it is hoped that it will be possible to give a detailed description of the solutions at a later date.

Conclusions

It is hoped that the analysis of the problem and the description of the solutions adopted for the three extensive groups in question, has shown that, not only is it possible for such an extensive system to bring about a set-up such that the generation facilities are balanced with respect to loads for each of the groups, but that a balance is obtained for the coordinated set-up of the three groups as a unit. That this has actually been accomplished can be seen by referring to curve C of Fig. 2. It will be noted that the combination shows an excellent and proper margin between load trend or expected load and facilities available to carry that load and yet the margin is not so great as to be excessive.

Again it is hoped that it has been demonstrated that the art of providing adequate generating facilities is a most complex one and is determined to a considerable extent by the area served, the location of water and coal within that area, the approximate layout of the system in question, the condition of the existing generating facilities, the availability of supplies from interconnections, and many other factors.

It is believed that it has been clearly shown that load expectation or long-term load trend, although difficult to obtain, is vital as a basic point on which to set up any rational scheme of increasing generation or supply facilities. The description of the detailed solutions worked out in the case of the three systems described in this article, has shown that it is not possible or practicable to standardize on a solution, and that size of units, pressures and temperatures cannot be standardized, and that size of boilers, types of bottoms and other similar features are not susceptible to standardization. Rather they are determined for a particular system by the location, size, load factor, requirements for modernization and numerous other factors peculiar to that system.

Nevertheless certain principles can be stated and followed. It is obvious, for example, that steam pressures have definitely moved today out of the economic range of the 250 lb. class; large boilers have in general moved out of the economic zone of stoker operation; long distance transmission of electric power is not economical. These are some of the fundamentals. Many principles of that type can be established as true today, and will probably be equally valid years to come.

Under these circumstances, the best thing one can do is to apply these principles and all the developments in the art of steam generation, power generation, power transmission, etc., to a solution of any individual problem of power supply. Such a solution will involve the balancing of a great many complex factors. But such a balance can be made and as a result of it, a proper solution obtained. Once a proper solution is obtained, it will yield two highly desirable and, frequently, difficult to attain results: First, it will give adequate facilities, i. e., facilities in sufficiently large quantities to be able to serve economically, with a proper margin of safety and with the proper quality of service, all existing consumers and care for any reasonably expected new load that may come on with the proper quality of service; second, it will give facilities which for a particular grade of service will provide a supply of power more economically than can be obtained in any other manner. These aims have always been and are bound to continue to be the goal of every power system planner or designer.

[5]For a description of Deepwater see Power Plant Engineering, p. 1205, Nov. 15, 1929.
[6]For a description of Stanton see Power Plant Engineering, p. 916, Sept. 1, 1927.

English Practice

Southwick Station installs two 37,500 kw. Ljungstrom turbines, the largest yet built in England

FOR SOME REASON often questioned by engineers, the Ljungstrom turbine with radial steam flow and two sets of rotating blades has never been fully developed in this country although successfully applied in large units in several European stations. Based on many years experience with 15,000 kw. units of this type, two of the largest Brush-Ljungstrom units yet built in England have just been installed in the Southwick Station of the County Borough of Brighton Electricity Undertaking (England).

These units are rated at 37,500 kw. and operate condensing at 650 lb., 850 deg. F. Due to the construction of this type of turbine two generators are used with the turbine set between them. Steam during the greater part of its expansion flows in a radial direction through concentric rings of reaction blading secured alternately to the faces of a pair of oppositely rotating discs, each of which is overhung from the inner bearing of one of the two half capacity alternator rotors. Each disc comprises three main sections connected together by radial bolts

which enable the portions to expand and contract relative to one another without the distortion that might be expected in a single disc subjected to the same steep temperature gradient.

In each turbine there are 57 rings of radial flow blading and two axial flow single rotation low pressure stages. The central position of the turbine in its casing enables a double flow arrangement to be employed for these last stages, each turbine disc carrying two rows of axial flow blades in addition to its share of radial flow rings. The four rows of stationary guide blades are carried in a frame built up of steel plates and supported in a central position in the turbine casing. This single cylinder turbine has no high pressure casing. The complete blade system is contained in the unlagged low pressure casing which is only exposed to the temperature of the exhaust steam.

Motor driven turning gear is provided for use in alinement and other tests when the plant is out of service, but as there are no heavy moving parts or long shafts in the turbine itself there is no need to rotate the turbine for long periods in order to avoid stresses during heating and cooling.

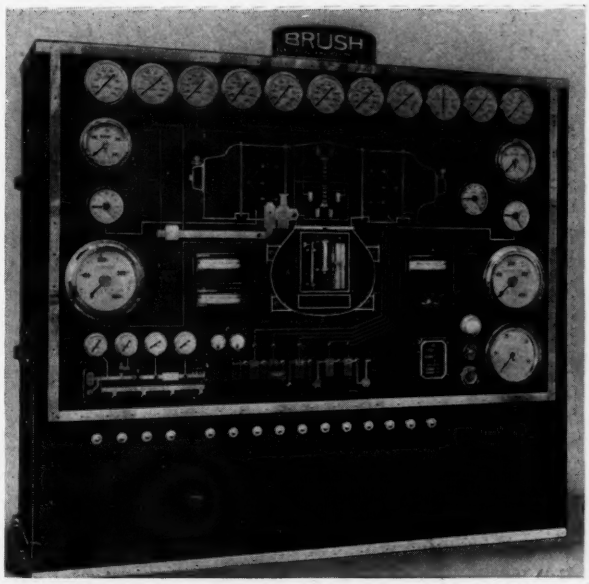
Alternators are rated for a total output of 37,500 kv-a., 0.8 power factor, at 8000 v., 50 cycle, 3 phase, when running at 1500 r.p.m. The stators are connected permanently in parallel and the rotors are connected electrically in series to an exciter in accordance with the customary arrangement of Brush-Ljungstrom turbo-alternators. The rotors are mechanically coupled directly to each half of the turbine blading. An axial type internal fan is fitted at each end of each rotor.

The exciter of the overhung type with a capacity of 126 kw. is of the six-pole type, shunt wound with interpoles and follows the normal construction of direct current machines. As the rotors are connected permanently in series and the stators in parallel, it follows that immediately excitation commences, the two alternators synchronize automatically. This occurs at a little below half full speed and thereafter the two sides, being in step, operate electrically as one unit.

The divided two-pass condenser is designed to maintain a vacuum of 29 in. at a load of 30,000 kw. when supplied with 31,000 g.p.m. of water at 60 deg. F. The condenser is fitted with ¾-in. O. D. aluminum brass tubes with Crane packing and has a total surface of 37,100 sq. ft. Duplicate full duty condensate pumps are provided, each being capable of withdrawing 550 g.p.m. of condensate from the condenser and delivering it to the suction of the low pressure feed pumps against a total head of 131 ft. The pumps are of vertical spindle type, and are driven by 55-b.hp. d.c. motors at 1000/1130 r.p.m.

In accordance with the specifications of W. N. C. Clinch, Engineer and Manager, there is no atmospheric exhaust valve of the dimensions usually associated with turbines of this capacity. Instead, there is an arrangement for gradually and automatically unloading the turbine as the vacuum falls below 24 in. of mercury and only an 8-in. atmospheric valve is installed.

To enable advantage to be taken of the speedy starting properties of the turbine, a quick start ejector has been provided, capable of raising a vacuum of 24 in. hg. in 3 min. There are two main ejectors, each of the three stage type with intermediate surface condensers. One of



The turbine room instrument panel gives the operator a complete picture of operating conditions

the ejectors uses the main condensate as its condensing medium, while the other, used only on low loads and when starting up, is supplied with sea water from a shunt off the circulating water supply to the main condenser.

A float control valve is fitted to the condenser to work in connection with the closed feed system of the station. The condensate line is connected to it through a branch after the gland heater, and the valve is so connected to both the condenser and the surge tank that a constant level of water is maintained on the suction side of the extraction pump.

Drains of all the bled steam heaters are cascaded and finally returned to the condenser. The two highest pressure heaters are fitted with automatic by-pass gear for the feedwater. The condensate passes in series through the main ejector condensers, a low pressure heater, a gland heater, a drain cooler and another low pressure heater to the low pressure boiler feed pumps. From there it passes through the two high pressure heaters to the high pressure feed pumps. The condensate temperature at the discharge of the last heater is 340 deg. F. at the most efficient rating of the turbine.

An ingenious instrument panel enables all operating conditions and the performance of the units to be observed from a point near to the main controls of each turbine. The illustration shows the panel built by the Brush Electrical Engineering Co. and installed with the first set. It is inlaid with an outline diagram of the complete installation.

Push buttons fitted at various points in the diagram enable the temperature at corresponding points of the actual turbine and alternator to be read on indicators mounted on the panel. The lubrication and feed heating systems are also shown on the diagram and all the important pressures and temperatures may be read in the same way. Inlet and outlet circulating water temperatures may be obtained by pressing appropriate buttons and the vacuum may be read on a Kenotometer situated in the space representing the condenser.

DIESEL CONTROL

Details of the control gear of a Sulzer two cycle marine engine

CONTROL OF DIESEL engines used for marine service is more involved than for stationary service because the engine must run in either direction. The control mechanism of large Sulzer marine Diesel engines is shown by the accompanying drawing. It may roughly be divided into three parts: the fuel control system; the starting control device; and an interlock system which affects the other two simultaneously and ensures reliable maneuvering.

The fuel control system comprises the fuel pump 4, fuel valve 3, levers 7 and connecting rods, which regulate and measure the quantity of fuel to be injected, but do not cut off or open up the fuel supply when the engine is stopped or started. In Sulzer marine engines with direct injection the fuel pump is operated by a symmetrical cam, which serves for running ahead and astern. Consequently, when reversing the engine it is not necessary to alter the controls of the fuel system.

Starting is effected by operating lever 10 which causes air to pass through the control valve 11 to the starting valve 12 and controls their opening and closing. A small plunger 9 is subject to the air pressure during the starting operation, with the result that it is impossible to move the reversing control during the starting period. This plunger operates a pin which engages in a slot in the reversing shaft as soon as this shaft is in the stop position.

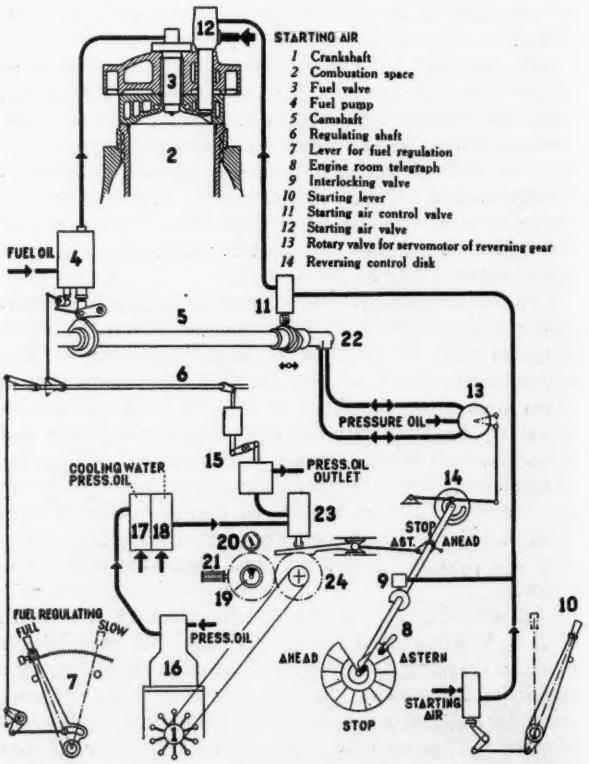
Reversing of the engine is effected through the engine room telegraph lever 8. By moving this lever an operating disk 14 is made to rotate and move a valve 13 by means of suitable rods. According to the position of the telegraph lever 8, this valve 13 is rotated mechanically into the ahead or astern position, so that pressure oil which is led to the valve acts on the piston of a servomotor 22 in the required direction. This piston moves the ahead or astern starting cams axially, thus bringing the appropriate cams under control valves 11. The cams are fitted on a sleeve which slides on the camshaft 5.

The interlock system prevents false maneuvers being carried out, stops the engine and gives an alarm in case of failure of certain essential services. For example, the apparatus 23 not only shuts off the fuel automatically when the reply signal is given to the order to stop and reverse, but restores the fuel supply automatically as soon as the engine is turning in the desired direction. Since these functions are automatic, there is no danger that the engine may run in the wrong direction.

The apparatus consists essentially of an operating disk 24, which is connected mechanically to the crankshaft 1, and of a valve block 23. Between these two lies a slipper, the position of which depends on that of the reversing mechanism or of the reply lever. If the engine has to be reversed from ahead to astern, the valve 23 is opened by the slipper, and oil under pressure is led to a servomotor piston 15, thus causing the rod 6 to bring the fuel delivery to zero.

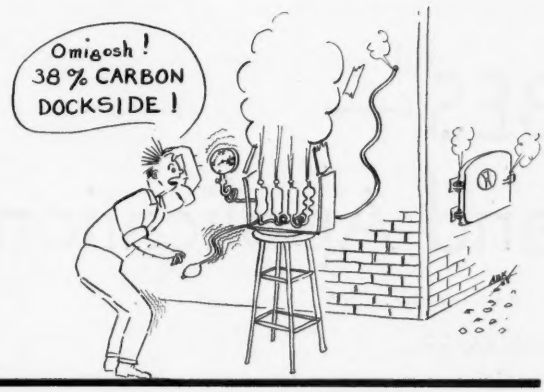
When the engine begins to rotate astern, the operating disk also turns astern and, by reversing a pawl, closes the valve 23 so that the servomotor 15 again sets the fuel pump on to delivery. Further safety devices are provided. The first, 16, is a governor, which operates, through 23 and 15, when the engine speed is too high. Servomotors, 17 and 18, are operated by the pressure of the lubricating oil and cooling-water respectively. As soon as the pressure in one of these supplies drops below a certain limit, the fuel regulation comes under the control of elements 23 and 15.

In addition to these a locking mechanism is provided which makes it impossible to start the engine unless the turning gear is out. The control pressure-oil system shown in the diagram can be changed over to compressed air if required by simply turning a cock. It is necessary to make this provision in case the safety devices 17 and 18 should operate while maneuvering the engine.



Diagrammatic representation of the control mechanism

Applied Principles of Steam Generation



An Open Letter To The Editor From Pulverizer Pete's Stooge

Dear Ed.:

All on account of you I am now pushing a broom around the wife's kitchen instead of being supposed to push it in the corners of the local powerhouse. I am at present engaged in contacting the Legal Aid Society, which will soon sue you for loss of job, defamation of character and alienation of wife's affection, not being able to afford a private lawyer. Maybe I will throw in what the chief did to me if I can decide whether it was mayhem or only attempted homicide.

It all happened this way. I'm sitting in the Chief's office doing nothin, on account of him being on his vacation, when I sees in the middle of his desk a book called Power Plant Engineering. I opens the book and looks at all the pickchers until I sees a story on how to run a boiler house by a guy what is called Pulverizer Pete. Now I have got the repitation of being the best broom leaner-onner in any plant west of the stachoo of liberty, an I figures if this guy can run a crazy idea into three issues of a technical book, well then maybe I can use some of his ideas while the boss is away and maybe get a raise when he comes back. Which I did, but not like what I was expecting.

So I goes down to the boiler room and starts to aplly the principals of efficiency, and first thing you know a gadget on top of the boiler opens up and begins shooting steam all over the place. So I gets a piece of steel cable and a pipe fitters helper and fixes the gadget so that soon there ain't no more steam comin out. Pretty soon I hears funny noises on the inside of the boiler, and when I opens the door and looks inside all the tubes which was nice and strait before, now looks like a corkscrew what has been on a binge. I figures this is swell, on account of Pete says that crooked tube boilers is better than strait ones anyhow.

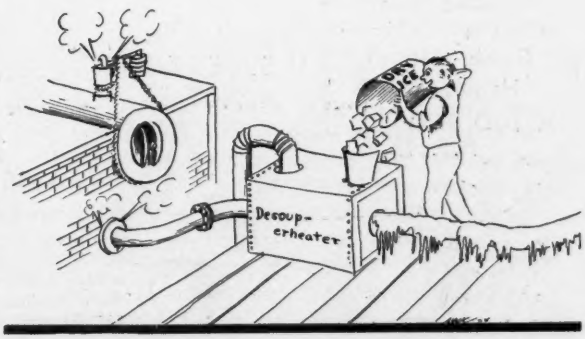
Then the superheater tubes get kinda warm and begin to sort of drip down into the furnace, and I thinks that maybe what we need is one of these hear separately fired desouper-heaters. So with my trusty pipe fitter, I hooks up the souperheater outlet to a coil in a box what has an inlet and an outlet. Then I goes down to the Eskeymo Pie man outside the plant and gets me some dry ice. I blows this into the inlet and it sure does cool down the superheat. Then I connects the outlet back to the boiler because I figured that was as good a place as any to put the used up gas.

After a while the test engineer comes around with his Or Sat and darn near blows the top off his funny glass jigger. He scratches his head and says what he has got thirty eight per cent carbon dockside. The fireman whistles and says that sure is some carbon dockside, but I didn't tell them about my new efficiency, wanting to surprise them. The test engineer figures that we're only using about five pounds of air for a pound of coal, and you gotta admit, Ed., that's combustion! Besides, the gas coming out of the stack was so cold that we was getting about 102 per cent efficiency, and I'd like to know how you can do much better than that.

Well sir, the next day the plants shuts down because we ain't done much maintenance work in long time anyhow, and I waits for the Chief to get back for to tell him what I have did. When the Chief hears about everything he gets awful mad because I am so smart and will maybe take away his job. So he says some very nasty words, and when I come to he fired me.

So now I have not got a job anymore, and can not afford to wait for my social security, so am suing you like I said before. Hoping you are the same.

Pulverizer Pete's Stooge.



I gets me some dry ice.

Part XXV

In this article we leave the purely theoretical and get down to brass tacks—we put the electron tube to work. For that, after all, is the ultimate purpose of any device and the electron tube is quite capable of holding its own when it comes to work. Three applications are described; the first an unusual one. The other two are of a more prosaic nature, but they are nevertheless interesting, since they deal with furnace control.

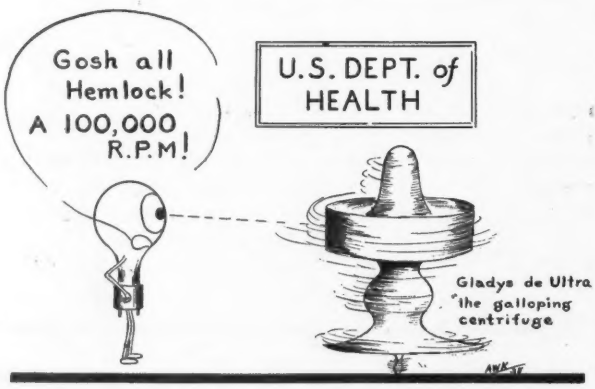
ELECTRON TUBES— Principles and Applications

By A. W. KRAMER

PHYSICISTS in the laboratories of the U. S. Department of Public Health recently were confronted with an unusual but interesting problem. This involved the measurement and control of the speed of an ultra-centrifuge rotating at 100,000 r.p.m.

The centrifuge used in this laboratory is driven by a stream of compressed air and like others of its type rotates on a similar stream for its bearing. The obvious method of measurement, that of using a neon-lamp stroboscope operating at a submultiple of the rotational speed in this case was open to three objections: (1) the method would not permit accurate measurement rapidly because the submultiples would be too close together on the commercial forms of stroboscopes available; (2) safety considerations prevented the operator from being too near the centrifuge when operating at such speeds, and (3) it provided no means of controlling the speed.

A new method recently proposed uses a General Radio Electronic Frequency Meter to indicate the speed. A beam of light is reflected from the surface of the rotating element on the centrifuge and falls on a photo-electric cell. A black spot painted on the rotating surface interrupts the light once each revolution. The amplified output of the photocell is then applied to the electronic frequency meter which indicates the speed directly in revolutions per second. Carrying the project one step further, a marginal relay in the d.c. meter circuit is then used to control the pressure of the air stream driving the centrifuge, providing an automatic speed control.



This application of electron tubes to the solution of a difficult practical problem shows how the electron tube can be made to accomplish things that cannot be done in other ways or as simply. This, it is true, is an unusual problem, one that does not occur very often, and this was one of the reasons it was selected. The principle reason for presenting it here, however, is because it involves the use of all of the fundamental types of tubes we have considered in these articles. As will be shown, it makes use of the photoelectric tube, the cold cathode glow tube, the high vacuum amplifier and the gas filled hot cathode tube in both the diode and triode forms.

The circuit arrangement is shown in Fig. 1. At the left is shown the phototube which picks up the light impulse from the rotating element of the centrifuge. The output of this cell, which in common with the output of any photocell is extremely weak, is amplified by the 76 triode amplifier This is a high vacuum amplifier. The amplified output of this tube is delivered to the input transformer, T. The secondary of this transformer is connected to the grids of two gas-filled triodes, as shown. When the alternating voltage of this secondary is applied to the grids of these gas-discharge tubes, each tube becomes alternately conducting and non-conducting. At each transition of the current from one tube to the other, a current pulse is sent through the indicator circuit. Since the magnitude of each pulse is the same, the average current through the ammeter is directly proportional to the number of

pulses and therefore can be calibrated directly in pulses or cycles per second. The 84 full-wave, high-vacuum rectifier serves as an automatic switch which switches the indicator circuit from one side to the other.

The 874 as may be recalled from a previous chapter[1] is a cold cathode voltage regulator tube used to keep the applied plate voltage to the 885's below a certain limiting value. The actual plate supply circuit which furnishes the direct current for the 885's is not shown but this in the actual frequency meter uses an 82 full-wave, mercury-vapor rectifier.

Thus, it will be seen, practically every type of tube considered in the foregoing articles is used in this one circuit. Let us list them again:

1. The photoelectric cell
2. The cold cathode grid glow tube (874)
3. The high vacuum amplifier (76)
4. The high vacuum rectifier (84)
5. The mercury vapor rectifier (82)
6. The gas-discharge triode (885)

In presenting this application of the electron tube we have gone somewhat out of our way and it has plunged us rather suddenly into a circuit of considerable complexity, but as already stated it is unique in its use of so many of the fundamental types of tubes. The circuit itself is the one used in the standard General Radio Co., Type 834A Electronic Frequency Meter which measures frequencies from 0 to 5000 cycles per second. Thus for the measurement of the speed of 100,000 r.p.m. which corresponds to 1666 revolutions per second, it is ideally suited.

Flame Failure Control in Gas Fired Furnaces

Now let us consider an application of electron tubes closer to the power field and one considerably more simple than the one just described. This concerns a protective system applied to gas fired furnaces to prevent flow of gas to the burners if, for any reason, the ignition should fail. There are two such systems on the market, the Brown Instrument Co. "Protectoglo" system and the Wheelco Instruments Co. "Flame-otrol" system.

[1]Part XXI. Page 663, November, 1937.

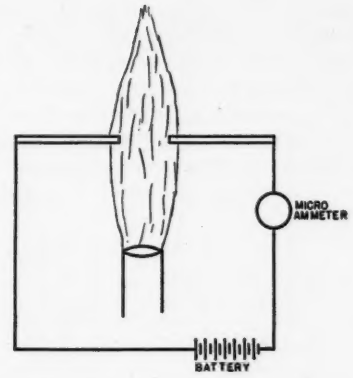


Fig. 2. A flame is a conductor of electricity. A flame is a region of intense ionization as well as de-ionization. The presence of a large number of free ions make such a region a fairly good conductor of electricity

Both of these systems make use of the conducting property of a flame.

A flame—any flame, regardless of how it is produced—is nothing more nor less than a region of intense ionization in which the ions are recombining and producing visible radiation. Now, it has been shown that any region in which free ions are present is a conductor of electricity. Thus, if a potential is established across any portion of a flame, an electric current will flow across that portion.

The process of combustion is one which continuously splits neutral atoms and molecules into positive and negative ions and it is the recombination of these ions immediately afterwards that produces the effect which we call a flame. The instant the process of combustion stops, the ions produced immediately recombine, the flame "goes out" and the region which it occupied almost instantly becomes non-conducting.

Thus, it is evident, that if an electric circuit containing a current indicating instrument and a source of electromotive force such as a battery is arranged as in Fig. 2 so that the flame becomes a part of the circuit, current will flow as long as the flame continues to exist, but the instant it goes out, the current will cease.

It will be noted in the diagram that a *micro*-ammeter is indicated as the current measuring instrument. A micro-ammeter is necessary because the resistance of a

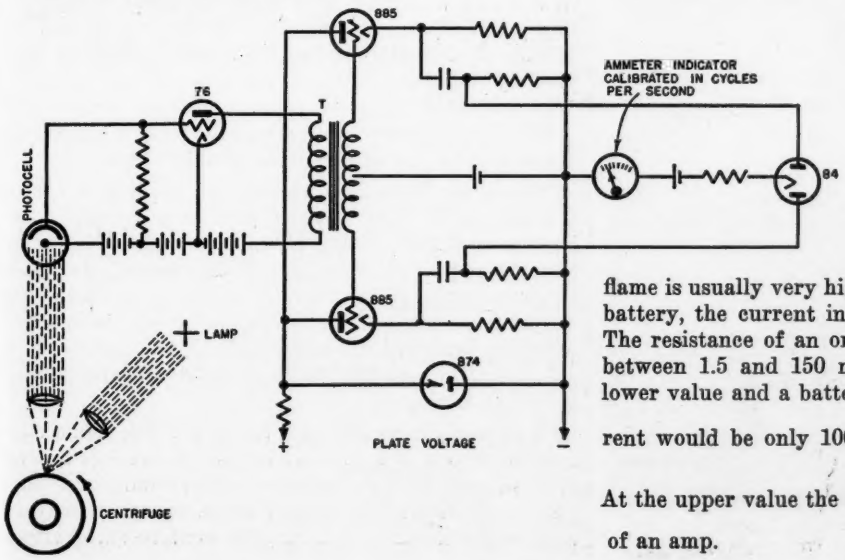


Fig. 1. Schematic diagram showing the application of a General Radio Frequency Meter to the measurement of high rotational speed by means of a photocell

flame is usually very high and even with a high voltage battery, the current in the circuit will be very small. The resistance of an ordinary flame may be anywhere between 1.5 and 150 megohms. Thus, even with the lower value and a battery of 1000 v. potential the current would be only $1000 \div 1{,}500{,}000$ or $\frac{1}{1500}$ amp. At the upper value the current would be only $\frac{1}{150{,}000}$ of an amp.

This is where the electron tube can demonstrate its usefulness and it does. By making the path through the flame, part of the grid circuit of an amplifier tube, minute changes in current through the flame can be made to control a relatively powerful plate current which in turn can actuate relays and other control equipment. In the case of one of the commercial forms

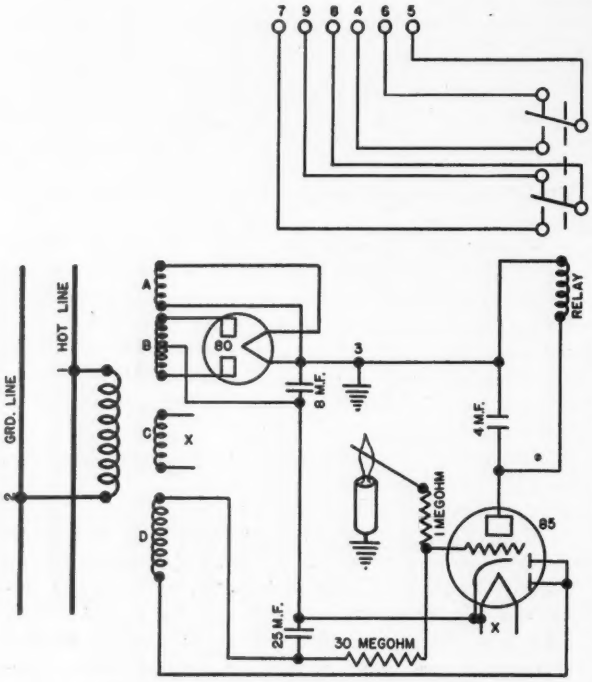


Fig. 3. Schematic diagram of the Brown Instrument Co. Protectoglo system

of this protective system, as long as the resistance of the flame is anything between 1.5 and 150 megohms, the control system serves to keep the gas flowing. If the resistance exceeds 150 megohms, there would be no flame and the control device would automatically shut off the gas. The actual manner in which this control is accomplished is different in the Brown and Wheelco systems but fundamentally the principle of using the flame as a conductor is the same.

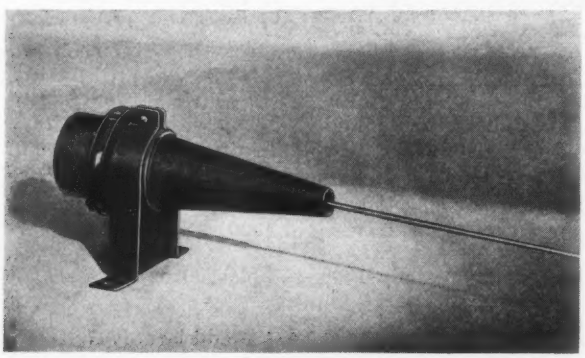


Fig. 4. The flame electrode of the Protectoglo system

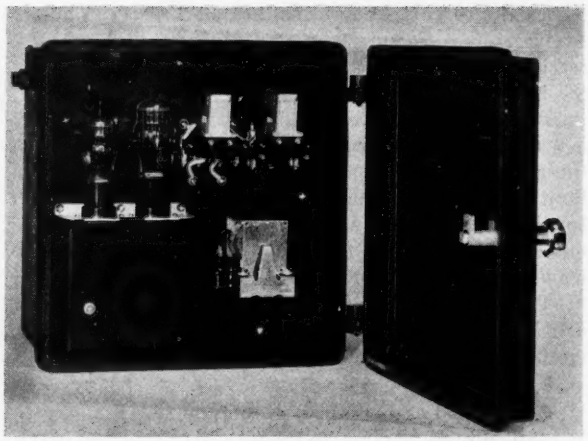


Fig. 5. The control unit of the Protectoglo system

The Brown Protectoglo system in its simplest form is shown diagrammatically in Fig. 3. In this particular arrangement flame failure merely shuts off the gas supply and it remains shut off until it is relighted manually. In an extension of this system, however, after the first failure of the flame, an automatic re-ignition system comes into action and attempts to re-establish the flame.

Two electron tubes form the heart of this system. One, an 80 type full wave rectifier supplies high-voltage direct current to the plate circuit of the 85 double-diode triode. A single transformer with four separate secondary windings supplies current for the filament and heater circuits of the 80 and 85 tubes respectively, plate current for the 85, and a biasing voltage for the grid circuit of the 85. The grid bias voltage is rectified by the diode portion of the 85 tube.

There is one feature about this circuit that is quite unorthodox. It will be noted that the positive side of the plate circuit is grounded at 3. This is quite unusual —usually the negative side is grounded. The purpose of this ground, however, is to place a positive potential on the grid of the 85 tube when the flame is lighted. This positive potential which is derived from secondary winding B, normally opposes the negative potential supplied by the bias winding D and since it is of a higher value the grid carries a positive charge. Under this condition, plate current flows and the relay is energized, keeping the valve in the gas supply line open.

When the flame fails, the current through it ceases and since there is no longer a positive potential opposing the negative biasing potential, the grid instantly becomes negatively charged. This cuts off the plate current, de-energizing the relay and cutting off the gas supply to the burner. The 1 megohm resistance in series with the flame is introduced to limit the current to a safe value in case the flame electrode should become grounded accidently.

This equipment is simple to install. The flame electrode is shown in Fig. 4. It is a stout metal rod of an alloy suitable for combustion chamber conditions. Supplied in a standard length of 18 in. though it may be had longer if desired, it may be bent to suit various

burner and combustion chamber arrangements. The rod is supported by means of a heat-resistant porcelain insulator to the outer end of which is attached a metal protective cover tapped for conduit fitting. The insulation has to be of a high order.

The control unit is shown in Fig. 5. The unit illustrated is the Re-lite unit which not only cuts off the gas supply upon flame failure but also attempts to re-establish it after a short interval. The two tubes are shown at the left and the plate circuit relay at the lower right. The two interlock relays which control the re-ignition may be seen in the upper right. The entire unit operates directly from the a.c. power lines.

The Wheelco Flamotrol System

The Wheelco Instruments Co. Flame-otrol is different from the system just described in that it uses only a single tube in a self-rectifying circuit. The tube used is the 53 type which is a twin-triode, that is, it consists of two triode sections with a common cathode and heater circuit. An internal wiring diagram of this system is shown in Fig. 6, but for purposes of explanation this circuit is shown in another form in Fig. 7. In this latter diagram the two triode sections of the 53 tube are shown as separate tubes, and of course two separate triodes could be used but it must be understood that in the actual device, these two triode sections are built into a single tube.

The equipment is energized from a single 60 cycle transformer having four separate secondaries. Two of these, S_1 and S_3 supply the plate potentials for the two triode sections, a third, S_2, supplies the bias potential for the grid of the first section (A) and a fourth, S_4, supplies current for the heater element of the tube.

Since current can flow only from the cathode to the plates of the tubes, the alternating voltages applied to the tubes will be rectified by the tube itself. Thus no separate rectifying tube is necessary in the Wheelco system.

When the flame is in contact with the electrode P, current from the secondary S_2 flows through the flame and the 200,000 ohm bias resistance X and back through the ground. This current through resistance X places

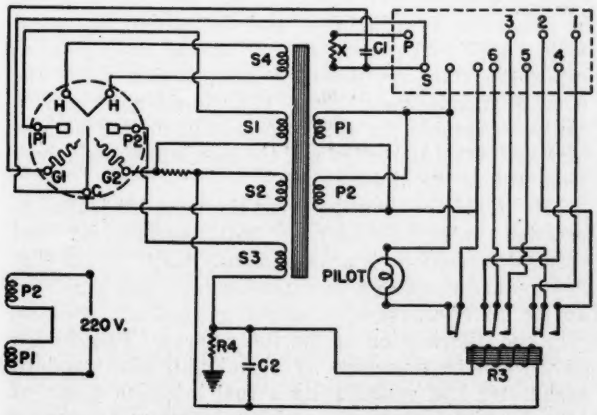


Fig. 6. Internal Wiring Diagram for the Wheelco Instruments Co. Flame-otrol

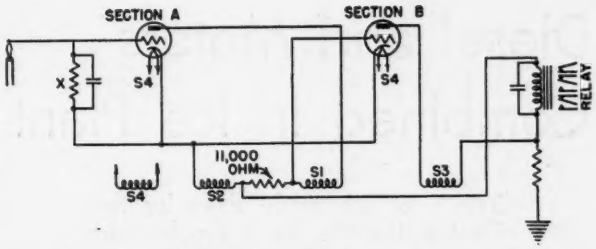


Fig. 7. Schematic diagram of the Flame-otrol system. In this diagram the two triode elements of the single 53 tube are shown as two separate tubes

a high bias voltage on the grid of the first section (A) thus causing the plate current in this section to drop to a low value. The plate potential of this first section, it will be noted, is the sum of the voltages of the two secondaries S_1 and S_2 these two being connected in series with an 11,000 ohm load resistance in between. The low plate current through the 11,000 ohm resistance maintains a low voltage drop across this resistor and consequently imposes a low voltage on the grid of section B. This low voltage on the grid of section B allows the normal plate current of section B to stay at a high value, keeping the relay closed, whereupon the contacts of the relay are in such position as to maintain the gas supply to the burners open.

Should the flame go out the following action takes place instantly: Grid bias on section A produced by the current through the 200,000 ohm resistor disappears, re-establishing normal bias on section A. The disappearance of auxiliary grid bias on section A causes an immediate rise in the plate current of section A. Plate current rise through the 11,000 ohm load resistor establishes a high bias voltage on the grid of section B with a consequent sharp drop of plate current in section B. The relay is thus de-energized and the fuel valve is closed.

Should the flame electrode become grounded, the bias placed on the grid of section A will be much larger than the bias normally established through the flame. By properly choosing the grid-voltage characteristic of the tube assembly, the plate current through the relay drops so that the relay opens under the conditions of either a grounded electrode or a flame-less condition in the furnace. The arrangement is such that an unsafe condition cannot occur.

These systems of protection have been applied to both high and low pressure gas-fired boilers as well as to industrial furnaces and ovens of the gas fired type. The flame electrode can be installed to operate from either the main burner or pilot light but it is usually installed to operate on the latter.

We have described these two systems in considerable detail because they show how electron tubes can be applied to accomplish an important function in a simple manner by two entirely different methods.

The real value of the electron tube in these applications lies in its ability to respond to extremely weak voltage impulses, and to translate these weak voltage impulses into relatively strong current changes which control relays.

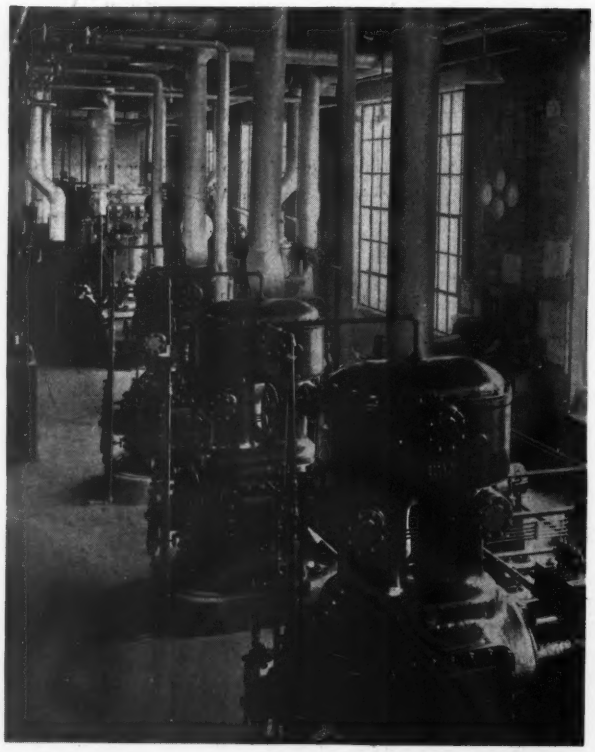
Diesel and Motors Combined In Ice Plant

330 t. of ice made daily by the Central Ice Co. by 3 synchronous motor driven and four Diesel engine driven compressors. The latter have dual-effect cylinders.

ONE OF THE FINEST ice plants in the East is operated by the Central Ice Co. in Brooklyn, N. Y. The building occupies a lot 240 by 100 ft. and the capacity is 330 t. of ice daily. Each of the two freezing tanks is 103 ft. long by 37 ft. 1 in. wide, equipped with 7876 sq. ft. of Vertiflow coil surface and 1462 all-welded ice cans measuring 11½ by 22½ by 48 in. The medium pressure air system is used.

Three of the seven 10 by 10 in. Frick compressors are driven by direct-connected synchronous motors. The remaining four, which have dual-effect cylinders, are driven in pairs by two 300-hp. Chicago Pneumatic Diesel engines, the compressors being placed at opposite ends of the engine shafts.

Compressors discharge into four vertical shell and tube Frick condensers, 38 in. in diameter and 14 ft. high, supplied with cooling water from a deep well.



Machine room of the Central Ice Co. The motor driven compressors are in the foreground, the Diesel engine units in the background.

City regulations require that water pumped from these wells be returned to the ground through a diffusing well. Due to short circuiting of the warm water, the resulting well water temperature is about 70 deg. F., giving a head pressure of around 160 lb. ga. If the well water were used at 55 deg. F., as originally intended, the head pressure could be cut to 135 lb. and the capacity of the plant increased to 350 t. of ice a day.

Water is precooled to 35 deg. F. before entering the cans in a Zig-Zag cooler, 16 pipes wide, seven pipes high and 13 ft. 6 in. long. This cooler is located in the penthouse, near the liquid precooler. Freezing is accomplished in about 31 hr. and 34 cans are harvested at one time. The water and liquid ammonia are precooled at 40 lb. pressure, this pressure being carried in the medium stage of the dual-effect machines. The system is charged with 21,500 lb. of ammonia. The ice storage room measures 98 ft. by 69 ft., 17 ft. high, and the temperature is held at 28 deg. F. by 4500 sq. ft. of 2 in. direct connected expansion coils.

Higher Engine Output

Supercharging and injection of fuel offer remarkable opportunities to improve present automotive engine performance.

BY IMPROVING the fuel mixture preparation it is possible to secure at least 150 lb. b.m.e.p. and tremendously increase engine output with an actual gain in smoothness, according to David E. Anderson, chief engineer of the Bohn Aluminum & Brass Corp. of Detroit. Investigation has developed an entirely new conception of what is necessary to improve engine performance and to show that increased torque and power is not necessarily accompanied by engine roughness.

Tests were recently completed in the Bohn Laboratory with a supercharger attached to a well-known popular engine with almost unbelievable results. Using the standard carburetor and intake manifold, the highest b.m.e.p. ever obtained was 123 and this was accompanied by roughness and detonation too great to be considered commercial. With the supercharger, using the standard 6.5 to 1 compression ratio, the b.m.e.p. was increased from 118, considered commercially acceptable, to 136. The maximum torque was increased from 160 to 186 and the maximum horsepower from 93.5 to 125 at 4000 r.p.m.

Mr. Anderson considers that the most efficient compression ratio, considering both commercial and thermal properties, is approximately 8.5 to 1, but that in standard practice a compression ratio this high cannot be used because of improper gasification, preparation and distribution of the fuel charge. This, he believes, can be overcome by abandoning the standard carburetor and substituting a fuel injection pump of a type which compresses a rich mixture at a pressure of 1000 lb. per sq. in. before injecting it into the com-

bustion chamber. This mixture, too rich to ignite, would then combine during its admission to the cylinders with air introduced, by suction or by means of a supercharger, so as to give the proper fuel-air ratio.

The type of fuel pump referred to utilizes heated and compressed air from the engine cylinders to form a heated emulsion of fuel and air, which is subsequently compressed and injected into the engine cylinder. The pump becomes a second stage air compressor, and the fuel air emulsion is delivered to the cylinder in a highly heated condition through open nozzles, which distribute the fuel in such a way as to form a thoroughly prepared fuel air mixture within the combustion chamber. Due to the fuel heating, the mixture ignites more readily and cylinder wall condensation is prevented. The time of introduction of the fuel emulsion into the combustion chamber depends upon the degree of turbulence obtained, or in other words, upon the combustion chamber size and shape.

With the substitution of an injection pump of the prepared fuel type, the operating cycle would be changed somewhat in order to gain added output and economy. This would not be in effect a Diesel engine, as the compression ratio would seldom exceed 8½ to 1, and the compressed charge would be ignited by a spark plug. However, the charging cycle would be altered to provide a perfect admixture of fuel and air within the combustion chamber rather than in a carburetor and inlet manifold. With the elimination of the carburetor and throttle valve, the volumetric efficiency is increased because the charging pressure could remain constant throughout the entire speed and load range.

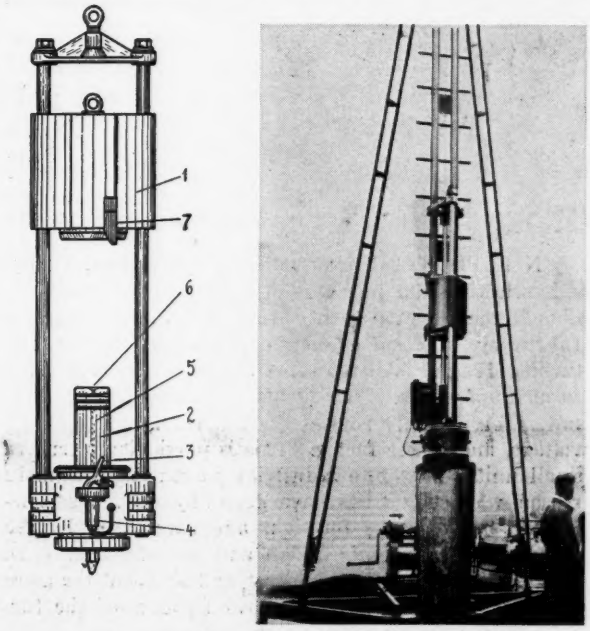
Injection Valve Characteristics

DISCHARGE CHARACTERISTICS of two similar injection valves operated by a single-cylinder fuel-injection pump were determined with an apparatus that measured the quantity of fuel discharged from each valve during every 0.5 deg. of pump rotation. From the tests, reported by Dana W. Lee and E. T. Marsh in N.A.C.A. Technical Note No. 600, it was found that similar discharges took place from the two valves at all pump speeds when the valve-opening pressures, the nozzle-orifice diameters, and the injection-tube lengths were the same for both valves.

Under these conditions, the effects of changing the pump speed, the pump throttle setting, or the nozzle-orifice diameter were very similar to those occurring with a single-injection valve. By a proper selection of discharge-orifice areas and valve-opening pressures it was possible to obtain a great many combinations of discharge quantities, discharge rates and injection timings for the two valves. A series of tests using injection tubes of unequal lengths for the two valves showed that under these conditions the injection timing and the fuel quantity discharged from each valve varied widely and erratically with changes in the pump speed.

Diesel Pile Driver

DRIVING PILES by the direct application of forces developed in a Diesel cylinder is accomplished by a hammer developed by Delmag and marketed under the appropriate title of Diesel-Ramme. The cap 1 moves up and down on two vertical guides, and, being hollow, acts as a cylinder. As the cap falls over the fixed piston 5, a charge of air is compressed and near the bottom of the stroke, the guillotine 7 strikes the fuel pump lever 3 to inject a charge of oil up through the piston. The resulting explosion lifts the cap on the guides and the cycle is repeated as long as the fuel in the tank lasts or until the hammer is shut off. The travel of cap 1 may be regulated by means of a cable control to the fuel pump 4.



Drawing of the Diesel pile driver and on the right one of the units in service

The Diesel principle is used on this pile driver. Cap 1 falls over piston 5 and compresses a charge of air. Near the bottom of the stroke guillotine 7 strikes fuel pump 3 injecting a fuel charge which again lifts cap.

To start the hammer, cap 1 is lifted to its highest position by means of a winch and held there by a latch until tripped. Inasmuch as the piston and cylinder are exposed directly to the air during most of the stroke, no additional cooling is necessary and the air swirl, resulting from the sudden withdrawal of the piston, gives sufficient scavenging to result in satisfactory combustion.

At present two sizes, one with a falling weight of 300 kg. (660 lb.) and one with 450 kg. (990 lb.) are being produced commercially and a heavier 1000 kg. (2200 lb.) model has been developed. The total weights are about double the above values.

MODERN TURBINES

Fundamentals of The Turbine-Generator*

By
J. M. LYONS
Generator Engineering Dept.,
General Electric Co., Lynn, Mass.

AN IMPORTANT transaction is represented by the selection and purchase of a turbine-generator set. Should the selection then consist only in making careful surveys of steam conditions, steam performance, and turbine design? All too often the generator is selected as an appendage to the turbine—necessary, it is true, but involving only routine considerations of capacity, voltage, and power factor. This is particularly true of small units going into industrial plants, and the main reason why such units have generally proven so successful has been the foresight and care taken by the manufacturers in their design and manufacture. Most purchasers apparently would rather talk about the more spectacular and easily understood features of the turbine, than to specify the generator characteristics in any detail.

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Anything else today sir?
O yeah—and you might send me a generator to hook on to it.
SAMPLE
TRY OUR SYNCHRONOUS CONDENSERS
SPECIAL SALE ON 85000 KW. TURBINES ONLY 6 TO A CUSTOMER

All too often the generator is selected merely as an appendage to the turbine

But, is the generator so dull and uninteresting as it seems to be? Not when it is realized that the design may embody many startling features as well as more common ones. For example, it takes as many as 40,000 separate laminations to build the core of a 7500-kw. generator—each one punched, annealed, enameled, and hand stacked. Then again, there is enough stored energy in the rotor of a 7500-kw. generator all the time it is running to lift a 5-ton truck nearly twice as high as the Empire State Building, if it could be so utilized. And did you realize that in order to ventilate a 95 or 96 per cent efficient generator, it is necessary to circulate a weight of air equal to the weight of the whole generator every 45 minutes? Or, that it is possible in certain sizes of generators for the conductors to carry sudden short circuit currents almost as large as the current of a lightning bolt, and yet be braced so carefully that they do not budge a fraction of an inch?

These are startling facts, but there are many other generator features equally as interesting, and often more important to a proper understanding of the characteristics which should be found in modern turbine-generators. What are some of these characteristics, i.e., what features help make a good generator? Briefly summed up, the generator should have the right kind of insulation, it should have a low telephone influence factor, it should have reactances which will limit short circuit currents to permissible values, and it should have proper stability. The last named is one of the most important characteristics and will be considered first.

It is first necessary to make clear what stability is, and what constitutes a stable generator. *A stable generator will keep on carrying the load even when subjected to wide fluctuations in the load demand. It will not lose voltage when ordinary amounts of load are sud-*

denly thrown on. An unstable generator may easily "give up the ghost" and drop out of step with the electrical system following relatively small load changes, resulting in service interruptions. It has no reserve; no margin, to carry through emergencies successfully.

The requirements for stability should be met under any reasonable fault conditions—short circuits, grounds, sudden load changes, etc.—which might occur on the system. Extreme conditions such as direct lightning strokes on the line near the generator, or sudden three-phase short circuits at the generating terminals, need not be considered, since the generator will certainly be taken off the line immediately under any such emergencies.

Maintenance of synchronism involves questions of "synchronizing power" and "load angle". Maintenance of voltage involves questions of "excitation", "power factor", and "saturation". These features of generator operation were discussed fully in a previous article,[1] and it is only necessary here to repeat the most important conclusions which were brought out.

1—Electrical power is produced in a generator by the cutting of electrical conductors with magnetic flux. Under load conditions the presence of current in the armature conductors causes the flux to be shifted from the pole centers. "Synchronizing power" is the power exerted by the magnetic field on the rotor under such conditions. "Load angle" is the angle between the center line of the rotor pole and the center line of the shifted flux field.[2]

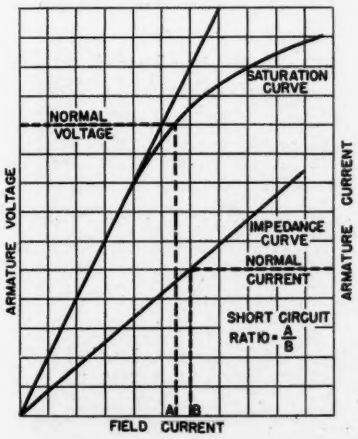

Fig. 1. No Load Saturation and Short Circuit Impedience Curves of a Typical Turbine-Generator

2—The generator is excited by direct current from a separate source, and the excitation can be adjusted independently of generator speed, load, or voltage.

3—The power factor of the load attached to a generator determines how much armature current and how much field current must be carried on the generator to deliver the required kilowatt load at the required voltage and frequency.

4—When the generator is operating in parallel with others, weight of steam flow through the turbine at constant steam conditions determines kilowatt output, and at a given kw. load and voltage, field current determines armature current and power factor.

5—In general, reductions in power factor from unity in the lagging sense correspond to increases in field current *(at constant armature voltage and current)*, while reductions from unity in the leading sense correspond to decreases in field current under the same conditions. Also, *at constant power factor*, increases in armature voltage at constant armature current, or increases in armature current at constant voltage, correspond to increases in field current, and vice versa.

6—Saturation of the iron portions of the magnetic field paths in a generator affects the portion of the field current which produces the main magnetic field, but not the portion which balances the effect of armature reaction. When saturation is present, more change in field current is required to make a given change in armature voltage than would otherwise be the case.

IN THIS day and age when this poor old dizzy world is all but tottering on its foundations, when the forces of economic royalism and leftism alike are taxing the synchronizing power of civilization to the utmost, when tradition is being thrown to the winds in all directions and when "swing" is in the ascendency the world over it is about time someone had the good sense to write an article on the fundamentals of stability. A whirling generator is about the last place on earth where one would look for stability yet strangely enough as Mr. Lyons, still our guest author, points out almost any degree of stability desired can be found in the modern electric generator. As a matter of fact, if we knew as much about the stability of political and social economy as we do about generators many of our present day worries would vanish and we could all live happily and peacefully ever after.

A study of stability problems immediately brings out one very important point. *The stability of a generator supplying power to a system is as much a function of the load characteristics as it is of the generator characteristics.* For example, suppose it is required to estimate the voltage drop suffered by a turbine generator when a large induction motor of a certain size and type is suddenly thrown on the line. The estimate can best be made by analyzing the system as a whole. This involves determining the sizes, types, operating conditions, etc., of all the motors already on the line, especially the way in which their currents and power factors vary with drop in voltage, and then combining these characteristics with the characteristics of the generator itself, calculated at the same terminal conditions.

As an illustration of the effect of load characteristics it is found that the power factor of an induction motor improves (increases toward unity) as the voltage drops—assuming constant load. Even though the current increases at the same time, the net effect is to help the generator in keeping up the voltage.

If it is not possible to make a complete analysis of the system to which a new generator is to be connected, it is necessary to specify a generator which is known to be stable enough in itself to operate satisfactorily on systems similar to the one in question.

This brings up the question—how is the stability of an A-C generator specified? In the past, the most common method was to call for a certain "short circuit

[1]Page 254 April issue.
[2]Neglecting the resistance and reactance drop in the stator winding.

ratio''. Referring to Fig. 1 this is simply the ratio of the field current required for normal armature voltage on open circuit to the field current required for normal armature current on sustained short circuit. The ratio in present-day generators usually lies between 0.8 and 1.1. For normally designed machines, higher ratios mean greater ''stiffness'' of coupling between armature and field, and hence presumably more stability.

Short circuit ratio, however, has one serious defect in completely specifying stability. It says nothing about saturation of the magnetic paths, which condition is known to have a vital effect on the stability of the generator. *Between two generators having the same short circuit ratio, the one with the greater degree of saturation at normal voltage will be more stable than the less saturated machine.* Therefore, in order to provide a better measure of stability it is desirable either to specify both short circuit ratio and saturation, or better yet, to devise another criterion which includes both factors in one quantity. Several such factors are available.

The two most common methods of showing stability are known as ''kv-a.-Margin'', and ''Power-Angle Characteristic''. These will be described in the following paragraphs. Kv-a. margin is most useful in showing stability when the generator is carrying a load while it is isolated from any other system or generator. The power-angle characteristic is generally used in studying stability of a generator operating in parallel with other generators on a system, and also for analyzing whole systems for stability.

Kv-a. Margin will be considered first. In Fig. 2 is shown a typical voltage regulation curve of a turbine generator when operating at a constant field current equal to the full load current and at constant power factor. By multiplying together corresponding voltages and currents a ''kv-a.'' curve is obtained. The kv-a. margin is the amount the peak kv-a. exceeds the normal kv-a. expressed in per cent of normal. In the typical example illustrated by Fig. 2 the margin is about 4 per cent. The peak kv-a. increases with increasing field current at constant power factor, and with increasing power factor (proceeding from lagging P.F. toward unity), at constant field current. The significance of the shape of the kv-a. curve is that beyond a certain point, increases in armature current produce reductions in voltage which

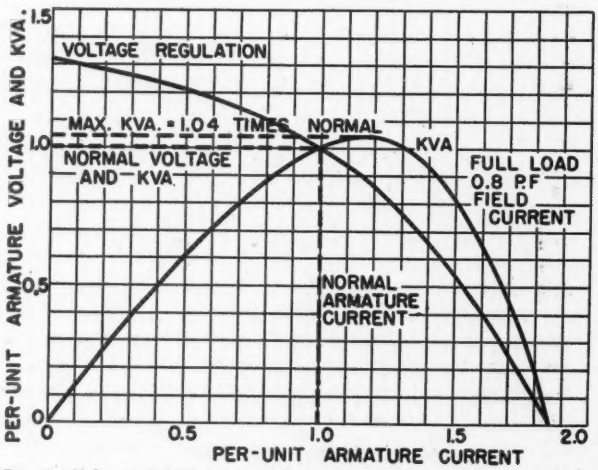

Fig. 2. Voltage Regulation and kv-a. Curves of a Typical Turbine-Generator

more than offset the increases in current, and less kv-a. can be carried. This continues until under-voltage relays trip off enough of the load to let the voltage recover again. A reasonable amount of kv-a. margin at rated field current and power factor for the usual type of load is about 3-5 per cent. For special cases where the load consists mainly of large motors a higher margin is desirable, say 5-10 per cent.

The other way of showing whether a generator will have satisfactory stability characteristics under given operating conditions is to go back to the idea of ''synchronizing power'' and ''load angle''. It should be clearly understood at the outset that this way of looking at stability is the one most useful to the application engineers of large systems, and to the designers and application engineers of the manufacturer. However, it cannot be used by a customer to specify directly the stability required of the generator he is buying. An explanation of the fundamentals of the subject is included here in order to give as complete a picture of stability as possible. Even though not used directly it will give a better foundation for specifying stability by other means.

Referring to conclusion (1) in the first part of this article, generator power output corresponds to a shifting or ''stretching'' of the magnetic field from its position at no-load (like the stretching of a spring). The more the generator is loaded the more the field is stretched, until finally it is shifted more than half way between poles. When this happens, there is nothing to hold the rotor in synchronism with the load and it slips ahead two poles, with a corresponding surge in armature current. The generator is, of course, unstable when operating under such conditions. The maximum power output for stable operation therefore corresponds to a shift in magnetic field (load angle) of one-half pole pitch, or 90 electrical degrees.

A graphical description of the foregoing is shown in Fig. 3. The curves indicate how power output varies with load angle at constant terminal voltage and neglecting generator saturation and resistance in generator lines. The curves are for different excitations, one for full load 0.8 P.F. and the other for full kv-a., 1.0 P.F. The maximum power output at 90 electrical degrees is clearly shown in each case. If the generator operates to the left of this point it is stable; if it tries to operate to the right of the point it is unstable. If the generator slips over into the unstable region it can be pulled back only by reducing the connected load or by increasing the field excitation.

It is interesting to note that a normal generator operating at full load 0.8 power factor lagging at normal voltage has a load angle of about 30 electrical degrees, and theoretically could deliver a maximum power equal to approximately twice full load if no limit were set on temperature rise. The generator operating at unity power factor at a kw. load equal to the kv-a. rating will have a load angle of about 55-60 electrical degrees and a maximum power only about 20 per cent more than the power output at its operating point, under the same conditions.

It may be wondered why a reasonable kv-a. margin on an 0.8 P.F. generator is set at only about 3-5 per cent, while the margin in synchronizing power may reach 100 per cent at the same field current. The reason for the

difference lies in the fact that the kv-a. curve applies to the condition of constant power factor on the generator (as well as constant field current), while the power-angle curve is calculated on a basis which is independent of power factor. If the generator is operating in parallel with others, with no voltage regulator, and the generator load is increased while holding constant field current, the generator power factor will adjust itself to the increase in load. It will shift toward leading power factor, so that a greater maximum power output can be obtained than if the power factor were held fixed at the initial value.

An important point to remember in studying Figs. 2 and 3 is that *the margin of stability is increased by increasing the field current.* If this can be done as fast as the load increases, the generator does not require so much margin at rated conditions for the same relative stability. This effect is approximated by the use of a reliable quick-acting voltage regulator. Such a device is particularly valuable in industrial plants where sudden load changes are commonly found. By using a regulator which begins to produce a change in field current within 0.05 to 0.1 sec. after a fault or load change, a burden is taken off the generator. The generator then does not have to carry continuously as much field current as would otherwise be required to operate successfully through the disturbance. Hence the generator can be made smaller and more efficient.

However, if it is thought that the regulator may be out of service at times, and the same stability must be maintained at these times as with the regulator, it is necessary to take this fact into consideration when specifying the generator. The generator stability as specified by kv-a. margin, or by synchronizing power margin, at rated conditions must then be greater than it would otherwise need to be.

By this time the reader has probably reached the conclusion that the subject of generator stability is inherently a complex one. Its importance in modern generator applications, however, is in direct proportion to its complexity. Formerly, the apparent difficulty of the subject and lack of knowledge concerning it have often caused stability to be neglected in specifying generator characteristics.

Contrast the conditions years ago with what they are today. Generators were then made over-size mainly to obtain the close "voltage regulation" (rise of voltage when full load is thrown off with constant field current) which was thought necessary with the lack of good voltage regulators at that time. Modern generators are not required to have so much extra "stiffness", because of the better voltage regulators now available, and because of a better understanding of real stability requirements.

Modern standard generators are designed to have sufficient stability for average power plant conditions. In these generators stability is considered along with other important features like reactances, efficiencies, and heating to obtain the best overall design. Where unusual service conditions (like full voltage starting of large motors, or connections to long transmission lines) are not going to be present, or where the consequences of voltage dip are not serious, it is best to specify a standard generator.

When unusual conditions are known to be present or are expected in future operation, it is advisable to present all the necessary information to the manufacturer so that the best generator can be designed to take care of the unusual stability requirements.

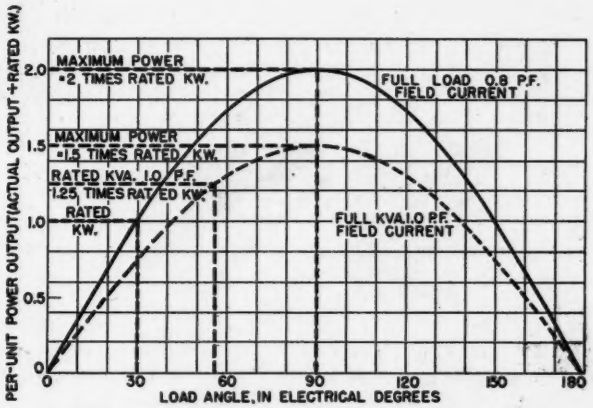

Fig. 3. Synchronizing Power—Load Angle Characteristics

No attempt was made in this article to consider the effects on stability of such things as speed of response of excitation systems, time required to remove faults, and other features which often enter into the problem. These are often important, but require more development than could be given here. A careful reading of this article will however bring out the fundamental points which it is well to understand when considering the stability of turbine generators, and will thus aid the user to specify equipment best fitted for his conditions.

THE AIR IN TRANSFORMERS to be oil-filled can either be pushed out by the entering oil or pulled out by a pump beforehand. The pumping method is better—30 per cent better as far as the insulation is concerned.

If transformers are placed in oil without vacuum filling, entrapped air is gradually absorbed by the oil and the insulation strength slowly rises, although not to a value as high as that secured by filling under vacuum. The absorption process is a slow one. Transformers have been known to fail because of entrapped air as long as a year and a half after being put into service. A second advantage of filling under vacuum is that the high insulation strength is obtained immediately with a resultant gain in reliability.

The method of filling is to place the transformer in a tight reservoir and exhaust the interior to a practically complete vacuum. Oil is then allowed to enter from the bottom while maintaining the vacuum until the coils are submerged.

Pumping out a transformer tank prior to oil filling results in a pressure applied to the tank walls. In the past the transformer tank would collapse under this external pressure. The octagonal-shaped tank recently developed for power transformers are inherently strong and can readily be braced for vacuum filling.

Vacuum filling is not limited to application at the factory, as with transformer tanks, properly braced, no other equipment than a small vacuum pump is needed. Transformers can be shipped nitrogen filled, as has been past practice, and vacuum oil filled in the field. Likewise the method can be extended to transformers whose windings have been exposed to the air for repair. (From the Westinghouse Engineering Progress report)

Fig. 1. Air view of Republic Steel Corp.'s new 98-in. continuous strip mill in Cleveland's Cuyahoga River valley. The large building at the right is the hot mill; the two long buildings in the center, the annealing and pickling departments; and the two long buildings to the left, the cold mill. The office and welfare buildings are seen to the rear of the 350,000-gallon water standpipe

Through Republic's New Strip Mill

By RALPH E. TURNER
Editor, Power Plant Engineering

A day of wonderment with officials and engineers of a modern steel corporation

IT WAS a letter from R. J. Wysor, President of the Republic Steel Corp., inviting the writer to be present at the formal opening of the world's widest and most modern strip mill, that took me to the Cleveland, O., plant of the Corporation to join in the ceremonies on March 15. Being the all-day guest of a very cordial group of corporation officials, and personally conducted through the mill is a pleasure the memory of which will remain a lifetime on the part of the recipient.

Thus it was that not only Mr. Wysor but Tom M. Girdler, Chairman of Republic, C. M. White, vice president in charge of operation, I. N. Tull, electrical superintendent, and other officials of the corporation submitted to my detailed questions regarding features of construction and operation. As we approached the new mill, Mr. White pointed out from our position on the bluff overlooking the Cuyahoga River how the mill buildings covering 21 acres stand on a 182-acre site, part of which is land which was made by changing the river channel, requiring the movement of more than a million yards of dirt.

"This mill," he stated, "is the largest, fastest, and most modern continuous strip mill in the world. It can roll strips 98 in. wide from slabs which speed through a series of electrically controlled roughing and finishing mills to the coiler almost a quarter of a mile away in as little as 240 seconds. Steel moves through this mill at speeds up to 2121 ft. per min. and is wound into coils weighing as much as 12,500 lb. a piece. The plant has a capacity for production of a million tons of hot and cold rolled sheet and strip per year.

"In this mill are the most modern types of handling equipment, electrical devices which give absolute control of working temperatures and speed throughout the hot rolling, pickling, annealing and cold rolling departments, and scientific lighting, all of which provide efficient and ideal working conditions throughout the plant, which has a potential employment capacity of over 2000 men. In addition to the mill proper are a large welfare building and an office building."

Power and Steam Supply

"With all this equipment and building space, Mr. White, you must have a tremendous power load and also a steam demand of no small amount, but I don't see any evidence of a power plant, smoke stack, coal pile and other equipment. How come?"

"You are right, Mr. Turner, we do use a lot of power. This, however, is purchased from the Cleveland Electric Illuminating Co., transformed and converted to suit our needs as you will find when we get into the mill. Steam, however, is another question. Note that insulated pipe line running under the sidewalk bridge over there? That is capable of carrying 100,000 lb. of steam per hour, the maximum requirements of the plant, from the power plant at Republic's blast furnaces at the Corrigan-McKinney plant. This steam line, over two miles long, is built entirely above ground and is supported on roller chairs setting on concrete piers.

"Initial pressure is 170 lb. and at a flow of 95,000 lb. per hr. the drop in pressure will be about 50 lb. The pipe

is made up of sections ranging in diameter from 10 to 16 in., welded the entire length and provided with expansion bends every 400 ft., each being calculated to take an expansion of 18 in.

"From this point you can also see the pumping plant. Normally 30,000,000 gal. of water is required by the mill for the cooling of machinery, for hydraulic sprays, rinse tanks and a hundred other industrial uses. In the plant there on the bank of the river are three 15,000,000 gal. double suction centrifugal pumps equipped with automatic control and priming systems. The entire mill supply is strained by two self-cleaning strainers with 1/16 in. perforations and insurance against interruptions in service is provided by a 350,000 gal. all-welded standpipe 125 ft. high. To supply water at 1200 lb. pressure for the sprays that wash the scale from the surface of slabs as they are being rolled in the mills, three 1200 g.p.m. multistage pumps are installed, driven by 1250-hp., 2300 v. induction motors."

"Now, Mr. White, that brings up this electric power question again, just how does that come into the plant? I don't see any conventional substation as used about industrial plants. Have you worked some tricks there too?"

"Indeed we have, but that will be understood better when you get in the electrical unit of the plant over there in the front, right corner of the main buildings. About the substation though, you will be interested to know that the banks of transformers are installed indoors, without vaults, and with the approval of the fire underwriters, because their cooling and insulating medium is pyranol, a liquid which has high insulating qualities, is non-inflammable and non-explosive. The electric supply coming to the plant is at 11,000 v., 3 phase, 60 cycles. Seven synchronous motor generator sets, totalling 30,000 kw. capacity, take current directly from the line. One bank of transformers rated at 12,000 kv-a. supplies current at 2300 v. for use on four 3000-hp. induction motors driving the roughing hot mills, hydraulic water pumps and small synchronous motors driving air compressors and run-out table motor-generator sets. Another bank with a rating of 3000 kv-a. delivers 440 v. current for lighting distribution and smaller auxiliary motors. All this you will see when we get inside the mill."

At the door of the mill it was my good fortune to meet Mr. Tull who was responsible for the electrical layout of the plant and it was he who conducted me through the entire plant, drawing attention to all features that might interest a power engineer.

Unique Lighting System

"First off, Mr. Tull, the lighting in this mill seems unusually comfortable. Am I confused by the sudden appearance of the sun from behind the rain clouds that have hung over us all morning, or have you really got something here?"

"The latter, if you please. The problem of lighting these high roof buildings, as you know, is difficult and it has been only in the last few years that much attention has been given to proper lighting of mills. There are two major considerations involved—quantity and quality. With the advent of the high intensity mercury lamp it has become possible to secure proper intensity and quality of light even in high roof buildings equipped with travelling cranes.

"This strip mill is lighted with a combination of mercury and mazda lamps, alternate lamps in each direction when possible. The light from an incandescent lamp is deficient in violet, blue and green, while the mercury lamp is rich in these colors, but deficient in red. A uniform quantity of the two mixed, approaches white or sunlight in quality. The mercury is twice as efficient as a mazda and has the property of showing an object in sharp detail. Its disadvantages when used alone are its inherent "lightup" time, several minutes, and the ghastly characteristic appearance of its quality. With the combination of the two, a glareless, nearly white light is obtained, making for safety and more efficient working conditions. If the mercury lamps are out on failure of power or accidentally turned off, the mazdas will relight instantly on restoration of service. We have provided a minimum of 7 foot-candles with a lighting intensity of 15 foot-candles used generally throughout the mill."

"You have indeed secured a very effective solution of the lighting problem and I presume the other electrical problems have been solved with equal satisfaction, but tell me, Mr. Tull, before we go into the motor room, just what you do in this mill. Not being a steel man a brief outline without too many technicalities is what would do me the most good. What I really want to get at is the solution of your power use problems. All I know now is that you start with cold slabs of steel and end with sheets, either flat or rolled as the customer requires."

Slabs Take a Ride

"Well, of course, that is stated entirely too briefly to even indicate that we have power problems, so let's start right here and get a visual picture along with the word description as we follow a slab through to the loading platform. Slabs of the proper quality steel come to this mill from one of the corporation's other plants. They are charged cold and heated to a temperature of approximately 2350 deg. F. in a battery of three end-charged, end-discharged, zone-controlled, triple-fired, continuous furnaces equipped with refractory tile recuperators. The maximum size slab that can be handled by these furnaces is 48 in. by 6 in. by 16 feet. Fifty tons per hour can be heated by these three units. To supply the required combustion air, exhaust fans driven by 50-hp.,

Fig. 2. Six-stand finishing train in the hot mill. Strip steel is rolled out of the last stand at a speed which reaches 2100 f.p.m.

a.c. motors are used. The fuel used may be either natural gas or coke oven gas or a mixture of coke oven and blast furnace gas. There are a lot of interesting details about these furnaces such as combustion control, insulation, water cooled skids, pushers, bumpers and even steel stacks, but they are not strictly down your alley."

"No, hardly, but I am curious about that scale on those slabs that come out here. It is, I understand, flakes of oxidized steel which you remove by jets of high pressure water driven on to the slab, the resultant steam expanding and removing the scale before the slab passes between the rollers. Is that a really important step in producing quality sheet steel?"

"Absolutely essential. The product would be of decidedly inferior quality without scale removal and, believe me, we fight scale at every turn in the process and the water jet is only one method. Right here is the first. Slabs, discharged at a temperature of about 2350 deg. F., are brought up to the hot mill over a heavy duty delivery table 118 ft. long driven by a 50-hp. d.c. motor running at 550 r.p.m. We call this first unit the roughing scale-breaker used for removing primary scale formed during the heating process. I'll not bother you by going into the dimensions as you can get them from this tabulation of data I'll let you take with you. This first unit reduces the slab thickness 15 per cent, enough to crack the scale which is then removed by a spray of water under 1200 lb. pressure.

"Next is the broadside mill 26 ft. farther on. In this four-high stand slabs may be passed straight through with the necessary reduction, or slabs up to 8 ft. long may be turned 90 deg. and rolled broadside for spreading to a greater width. For turning the slab, a 25-hp. d.c. motor is used. Then to insure proper entry of the slabs into the broadside mill a heavy duty, motor-operated slab pusher is provided."

"Now wait a minute. Doesn't that cross rolling change the texture or fiber of the steel?"

"Well, yes, it would if we stopped there, but in a strip mill the steel goes through so many more rolls all in the same direction that there are practically no cross fibers. Now, 24 ft. farther on is a slab reducer to true up the edges and to flatten out the slab for further rolling. The main drive for this is a 500-hp. pedestal type d.c. motor. The gear ratio is 100 to 1 and one revolution of the crank is completed in 12 sec. That enormous unit is of heavy cast steel construction with forged tension bars and has an overall length of 55 ft.

Motors Put on the Squeeze

"From here the slab goes through three roughing and six finishing stands. Such extreme accuracy is required here that the pass line elevation varies less than 0.004 in. Roll balance in all the mills is maintained hydraulically at all times. Oil-hydraulic pressure of 1500 lb. is maintained in two independent systems, each consisting of a 6-in. hydraulic accumulator, a 5-hp. a.c. motor and a 4.15 g.p.m. pump. The screwdowns are operated by two motors on the top of each housing, except on the roughing scalebreaker and on the broadside mill where there is only one. The two motors of each unit are interlocked by a magnetic clutch and are connected with the drives, one on each side of the housing, with flexible extension couplings. Each motor is connected with a cam type limit switch and each screwdown is provided with selsyn transmitters and receivers for screwdown indicators and remote control. These motors use d.c. and vary from 15 to 75 hp., as you will see by your tabulation.

"Another motor application on these rolls is a 200-hp. d.c. motor used to drive each edger. These edgers are attached to the entry side of each of the three roughing stands and their purpose is to control the width of the strip and give the edges the required roll finish. You will note here again the hydraulic sprays in the spaces between the three vertical edgers and the roughing stands. We just won't let the scale stay on the slab."

"In all your explanation of motors to drive gadgets on these mills, Mr. Tull, you have said nothing about the motors that drive the big rollers and I haven't seen a real he-motor in the place."

"That's an easy one. The big boys are on the other side of the wall there in what we call the motor room, only the shafts come through. We'll go in there shortly, after you get the idea of this steel rolling process. Just trail along with me, we'll make it snappy.

"You surely are interested in the temperature recording system we have here. When the slabs reach the delay table here, the temperature is very carefully watched by

Tabular description and motor equipment of principal mills

	No. of Rolls	Distance to next unit, ft.	Rolls: Work Roll Diam., in.	Rolls: Back-up Roll Diam., in.	Rolls: Roll Length, in.	Gear Ratio	Main Drive Motors: Horsepower	Main Drive Motors: Volts	Main Drive Motors: R.P.M.	Main Drive Motors: Type	Screwdown Motors: Horsepower	Screwdown Motors: Volts	Screwdown Motors: R.P.M.	Screwdown Motors: Type	Roll Speed R.P.M.	Strip Speed F.P.M.
HOT MILL																
Rough.Scalebr'ker.	2-High	26	28	-	56	12.2	800	2300	360	A.C.	35	230	575	D.C.	29.5	208.5
Broadside Mill	4-High	48	40	53	110	37.2	3000	2300	514	A.C.	75	230	525	D.C.	19.1	200
#2 Roughing Stand	4-High	56	27	53	98	16.2	3000	2300	514	A.C.	35	230	575	D.C.	31.6	223
#3 Roughing Stand	4-High	87	27	53	98	11.6	3000	2300	514	A.C.	35	230	575	D.C.	44.2	312.5
#4 Roughing Stand	4-High	145	27	53	98	8.4	3000	2300	514	A.C.	75	230	525	D.C.	60.7	429.1
Fin.Scalebreaker	2-High	25	28	-	98	11.5	600	600	150/600	D.C.	15	230	725	D.C.	13/52	92/368
#5 Finishing Stand	4-High	19	27	53	98	4.1	4500	600	125/250	D.C.	75	230	525	D.C.	31/61	217/434
#6 Finishing Stand	4-High	18	27	53	98	2.4	4500	600	125/250	D.C.	75	230	525	D.C.	53/105	372/745
#7 Finishing Stand	4-High	18	27	53	98	1.6	4500	600	125/250	D.C.	75	230	525	D.C.	78/157	550/1110
#8 Finishing Stand	4-High	18	27	53	98	1.2	4500	600	125/250	D.C.	75	230	525	D.C.	109/217	768/1537
#9 Finishing Stand	4-High	18	27	53	98	Dir.Dr.	4500	600	125/264	D.C.	75	230	525	D.C.	125/264	883/1866
#10 Finishing Stand	4-High	-	27	53	98	Dir.Dr.	3500	600	150/300	D.C.	50	230	550	D.C.	150/300	1060/2121
COLD MILL																
First Stand	4-High	16	20.5	53	96	6.79	1500	600	300/600	D.C.	50	230	550	D.C.	92/184	237/474
Second Stand	4-High	16	20.5	53	96	3.67	2500	600	225/450	D.C.	50	230	550	D.C.	127/254	329/658
Third Stand	4-High	-	20.5	53	96	3.02	2500	600	255/450	D.C.	50	230	550	D.C.	155/310	400/800

the operator who has a large visual indicator before him. Slab temperature is measured by rayo-tube type electrical temperature recorders, you might call them electron tubes, located over the delay table and elsewhere on the hot mill. These instruments make permanent, continuous records of the temperatures of each slab while it is being rolled. This delay table, where the steel strip is run back and forth two or three times until it cools to the proper temperature for the final rolling, employs two 55-hp. motors to drive all of its rollers through bevel gears and line shaft. They are of the reversing type and are controlled by the operator who is guided by the indicated temperature of the slab.

"Now following the delay table is the finishing scale-breaker back of which is a double spray of water under 1200 lb. pressure, then 23 ft. beyond is the first finishing stand of which there are six in the train. Then 13 ft. from the last stand is the flying shear for cropping and cutting sheets to desired lengths, the run-out table is next in line, extending 351 ft. to the coilers. On this run-out table for 120 ft. the sheet is sprayed with curtains of water for cooling purposes. For flat sheet delivery the run-out table continues 262 ft. beyond the coilers, the total distance being 613 ft. from the flying shear. The rollers on this table are driven by individual 4½-hp., 750 r.p.m., d.c. motors which give the table a top speed of 2350 f.p.m.

"This is the first mill to use d.c. motors for driving run-out tables and coilers. These motors are subdivided into groups up to 60 or more and each group is supplied with power from a d.c. generator."

"So with your sheet strips all coiled up or cut up into flats, your mill here calls it a day and let's somebody else work your product into manufactured consumer products."

"Not so fast, Mr. Turner, you have not seen the cold rolled mills yet. We'll step in there before going to the motor room we talked about, but I should mention that four upcut finishing lines are provided in the hot mill for different thicknesses of sheet. These sheets are put through a continuous normalizing furnace 60 ft. long and 9 ft. wide, and a batch pickler and scrubbing line for giving the white surface before they are ready for delivery.

Putting on the High Hat

"The coils from this hot mill, which are to be further processed and treated in the cold mill, are run through a continuous pickling unit for cleaning. There are two parallel lines of these each 505 ft. long. The strips are then recoiled and delivered to the cold mill where all the cold rolling equipment is located that might be needed to produce any kind of cold finish strip or sheet steel. Included in this equipment are a 98-in., 4-high, 3-stand tandem mill, two side trimming and flying shear lines, and upcut shear line, a single stand 98-in. combination sheet and strip mill, a single stand 98-in. skin pass mill, and a slitting line. Then between the pickling and cold mill buildings is the annealing building containing five batteries of four box type annealing furnaces."

"Well, you have made a fine story out of your steel making process, Mr. Tull, and I don't blame you for being proud of that clean, bright looking product over there, almost like the polished inside of a gun barrel. But we are not through yet. I just must see that motor room that has kept my mind wandering every few minutes during this trip."

"Yes, you have reminded me several times about that, so we'll back track a ways and really go into details. On the way over I'll try to give you a general picture and point out particular features when we get into the station.

Diversified Electrical Systems

"The mill has an electric power demand of 20,000 kv-a. which is supplied by the utility company. This is transmitted through an underground duct system operated at 11,000 v., 3 phase, 60 cycles. Secondary voltages of 2300 and 440 a.c. and 250 and 600 d.c. are used throughout the mill. For the roughing mill main drive motors, general service water pumps, spray pumps and air compressors, power is delivered at 2300 v. from a 12,000 kv-a. transformer bank. For lighting distribution and auxiliary motors throughout the plant a 3000 kv-a. transformer bank reduces the voltage from 11,000 to 440. For the hot mill finishing stands and the cold reduction mill stands, power at 600 v., d.c., is obtained from four 6000-kw. motor generator sets. The 250 v., d.c. supply is obtained from three 1500-kw. motor generators driven from the 11,000 v. service.

"It may sound unreasonable, but altogether throughout this mill, there are 1420 motors, varying in size from the giant 4500-hp. finishing stand motors, the largest ever used on a strip mill, to the fractional horsepower motors for operating clocks, 58 motors are of 100 hp. or more capacity and of these, 23 are of 1000 hp. or more capacity, the total motor capacity is 123,000 hp."

"That is a lot of motors and a lot of capacity tied up in some of them, these figures make me think of Congressional appropriations, but what I've been trying to figure out is your reason for what seems to be a rather promiscuous use of a.c. and d.c. in your motors."

"Really the choice of current was far from promiscuous, we did a lot of calculating and investigating before final decisions were made and in a number of cases our decisions were contrary to common practice. We think, however, that our choice has been wise and results are beginning to prove it.

The Why of A.C. and D.C.

"Take the roughing stands, for example, all five of the main drive motors are a.c. and the only substantial losses from the outside connection are those due to transformation and resistance. Three of these motors are provided with heavy flywheels and automatically controlled to smooth out the peak loads. They are of the wound rotor type controlled by slip regulation. Speed regulation here is, of course, important but not so exacting as in the finishing mills and it is not uncommon that these drives, equipped with flywheels, deliver nearly twice the instantaneous power input for the short time necessary to deliver a slab.

"The finishing units, however, have an entirely different load characteristic, considerably longer sustained and the speed regulation for continuous rolling is exacting to a high degree so the choice of d.c. motors for the main drives was indicated. These are operated in tandem, the type chosen being shunt wound, adjustable speed, con-

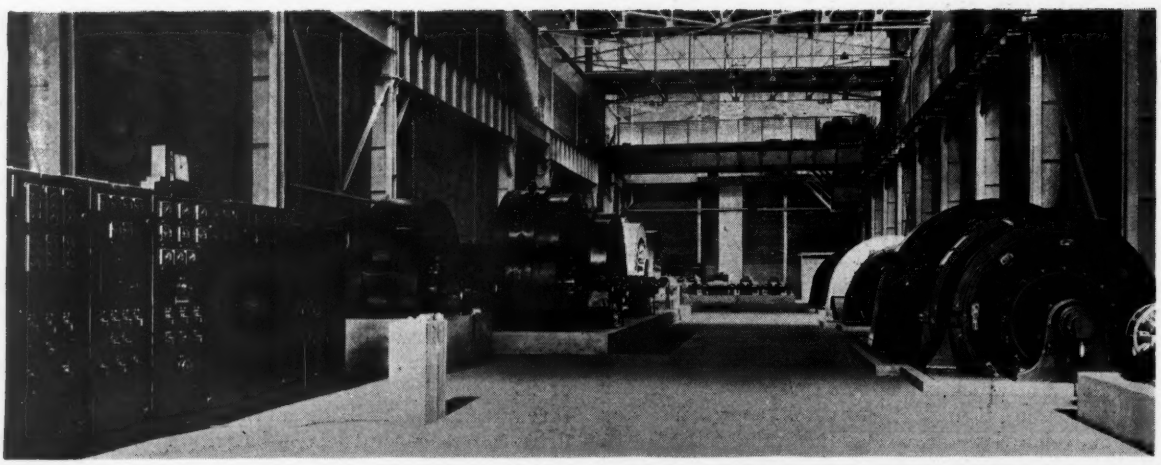

Fig. 3. Motor room which houses all the main drive motors for the hot mill. Three of the four 6000-kw. motor-generator sets are seen at the right, and the finishing scalebreaker and finishing mill main drive motors, at the left. This room is said to house the largest concentration of electrical rotating machinery, in power per square foot, of any industrial plant ever built

trolled from the bus. This, of course, entails expense necessary for motor generator current conversion and accompanying losses. When steel is rolled in all six finishing stands at the same time, it frequently puts a double load on all the motors, entailing a serious problem of power factor correction. With the finishing stands empty, the excitation of the synchronous motors must be as low as possible, yet be sufficient to prevent stalling when the load enters the stand. When the stands are full of steel, a maximum excitation is required. Correction is automatically applied as the load changes, and a minimum disturbance to the power system results. This benefits voltage regulation and makes for minimum power charges."

"I notice on this tabulation you gave me that all the auxiliary motors on these mills are d.c. I presume the reason governing this choice was principally because such motors are more easy to control both in speed and direction of operation."

"That's right. Similar reasons directed the choice of d.c. for the delay and run-out tables. Here, you remember, each roller is driven by an individual motor. This is general practice, but until this mill was built, these rollers were driven by a.c. squirrel cage induction motors. The operating requirements of these tables are severe, as the motors must start from rest, accelerate to a high speed, decelerate, stop and reverse in a very short time.

"To accomplish this, the a.c. motors have been operated in groups from a.c. generators driven by d.c. motors. The speed of induction motors varies directly with frequency, so that starting the d.c. driving motors connected to the a.c. generators, and raising the speed of the combination by controlling the speed of the d.c. driving motor, varying speeds of the rollers resulted.

"Although the requirements have been met more or less satisfactorily by this method, the overall efficiency is quite low and the investment in a good many cases higher than necessary on account of the converting equipment involved. For applying such a method to the 98-in. strip mill there would be required seven d.c.-a.c. 500 kv-a. alternator sets, adjustable speed, and one a.c.-d.c. dynamic braking set of about the same size.

"With power delivered from the supply mains in the form of alternating current, a conversion to 600 v. d.c. would be required with a conversion efficiency of approximately 85 per cent. Then, the d.c.-a.c. sets run from this converted source and re-converted to varying frequency and voltage a.c. for the individual induction motors on

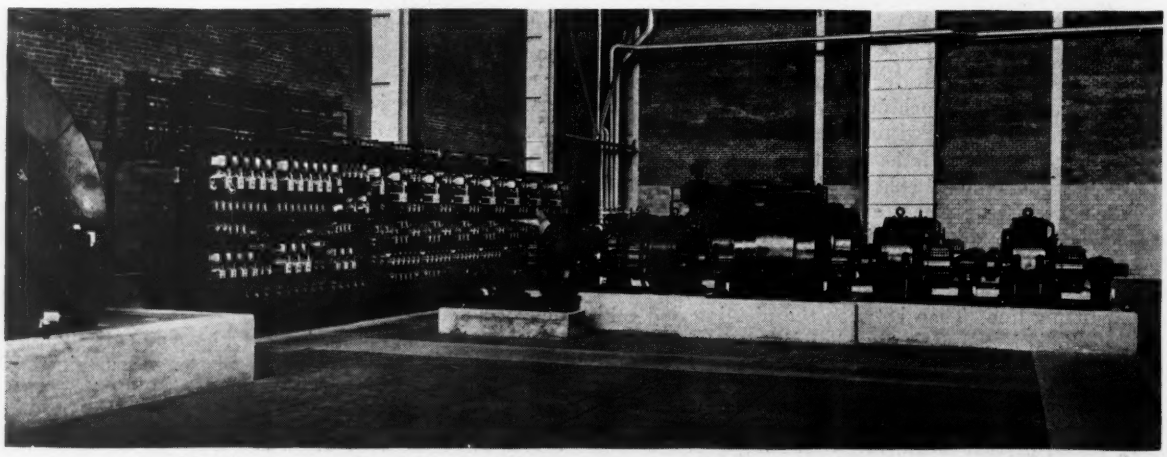

Fig. 4. Hot mill motor room showing the magnet control boards and motor-generator sets used for the d.c. runout table motors

the rollers. The second conversion is not as efficient as the first on account of the rapid acceleration and deceleration of the d.c.-a.c. set. This conversion efficiency is approximately 75 or 80 per cent, so that after two conversions, there is only about 65 per cent efficiency. Then, too, the efficiency of the roller motors is inherently low when operated in this kind of service. In this mill, therefore, d.c. is converted from a.c. with an efficiency of 85 per cent, using two motor-generator sets, each with several generators connected to a synchronous motor. These generators, by means of Ward-Leonard control, have their voltages raised, lowered and reversed as rapidly as desired by the operators, and the roller table and coiler motors respond easily, rapidly and efficiently.

"The roller motors are modified mill type, totally enclosed, shunt wound, and ball bearing. Their cost is somewhat higher than induction motors but the cost of the two motor-generator sets now installed is much less than that of eight which would be necessary by using a.c. roller drives and the building space required is only one-third. Instead of 75 ft. of magnetic control boards, only 24 ft. is being used. Circuit breaker requirements as well as ventilation and cooling equipment are also less with our arrangement. The power used is noticeably less."

Electrical Occupants of Motor Room

"With that rather extensive explanation of your power system, Mr. Tull, this motor room is doubly interesting and I see we have finally come to that really heavy power equipment you have been hiding from me. As I understand it, you have here all your high tension transformers, the large motor-generator sets, the main motors for the hot mill stands with necessary switchboards and other accessories."

"Yes, and there are lots of those accessories. Take this little device here for testing switches—it's just a little thing but our experience indicates that it may save a temporary, partial shut down—a little insurance, you know. The traveling crane of course is indispensible, the switchboards are the most convenient and reliable we could find. Then there are exciters, motor-driven controls and a thousand and one other devices necessary for furnishing the mill with all kinds of electric power service required continuously available. All of these are more or less standard designs but we have two things here that I am sure will interest you—the buses in the basement and the ventilating system.

"Now these bus bars, you will note, look like construction girders—they're plenty large and made of aluminum. They carry the 6000 v. direct current and the magnetic force set up between them is terrific during demand periods. Not only are these bus bars heavily braced but the positive and negative bars are placed on opposite sides of the 15-ft. aisle.

"As to ventilation, the provisions here have been laid out with extreme care. For cooling the main drive motors and motor generator sets there is required a total of 650,000 cu. ft. or approximately 24 t. of air per minute; and, as a rule, the atmosphere surrounding steel plants is neither clean nor cool, making it necessary to filter and usually to cool the air used for ventilation.

"It has been the general practice in the past to provide screening of the air, blow it into the basements and lead it up under the machine to be cooled, allowing it to be discharged into the motor rooms and exhausted to the outside of the building. Even with highly efficient screening, it is impossible to prevent the entrance of many hundreds of pounds of dirt, to the machines and rooms, clogging up air passages and noticeably increasing the temperature of the machines. Furthermore, the heat leaving the machines raises the temperature of the motor rooms to a point which physically affects the operating personnel, and even affects the life of the insulating material.

"To avoid these undesirable conditions, the strip mill motor rooms have been supplied with a recirculating air system, where about 5 per cent of the air required is drawn in and filtered at its entrance. This air is discharged into the basement and mixed with the air being recirculated and cooled through contact with radiator type water coolers. The water absorbs the heat from the coils of the coolers and passes on to the mills before finally being discharged to the sewer.

"As the cool air leaves the radiators, it is returned by fans to the main motor room, where it is down-drafted to the foundations, then through the coolers and back to the motor room again. As hot air is only in the machine

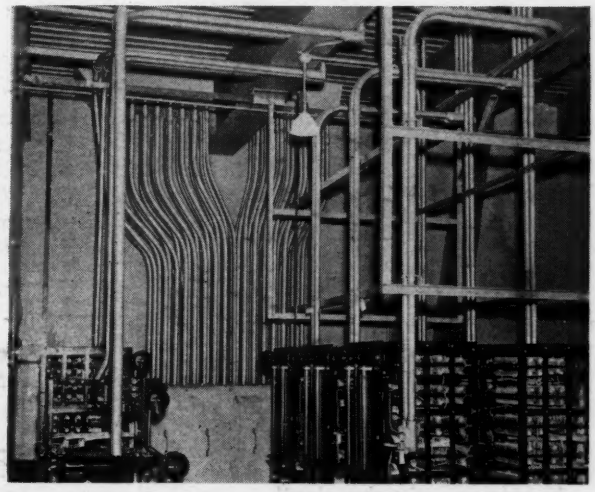

Fig. 5. Corner of the basement of the hot mill motor room, showing some of the conduit and control equipment

foundations, the basement and main rooms are all cool, and the radiation from the machines is rapid and efficient with a minimum amount of dirt brought into the buildings.

"Now that's my story, Mr. Turner, and I hope your readers will like it. You will get more about the mill and its development at the luncheon this noon and dinner this evening and here's the last bus waiting to take you back to the hotel."

Fruits from the Mud Flats

Thus ended my trip through this superlative new strip mill and the bus trip proved to be a period of reflection to me. From the top of the bluff came again to me the view of that new plant and it seemed almost incredible that the mud bottoms of the Cuyahoga Valley could in 10 months yield such a harvest, beneficial not only to the 2000 men employed therein but to workers located in every industrial section of the country for

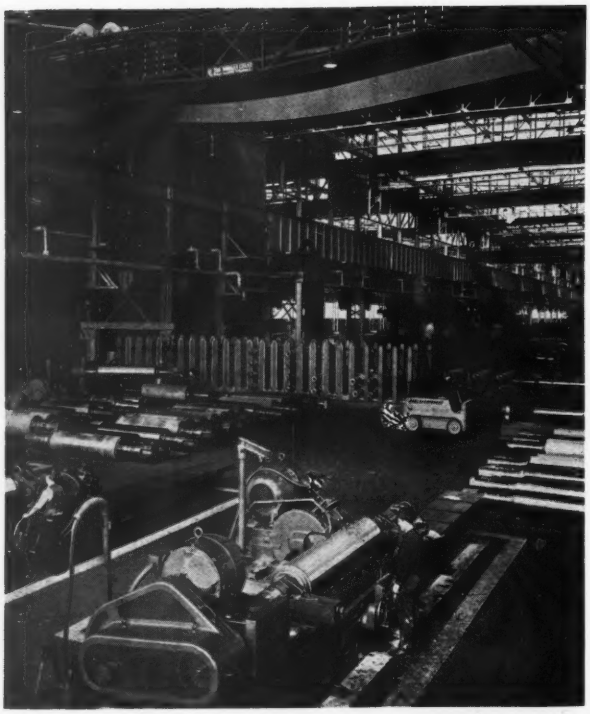

Fig. 6. Inside of cold mill building showing the roll shop in the foreground, the 3-stand tandem cold reduction mill center right.

their products have been used in the construction of this plant, to the miners of iron and coal who furnish the raw materials that supply the mill, to the utility employees who furnish the power, to the factory workers who use the products of this mill in the manufacture of consumer goods, and to the people on the street, on the farms and in the homes who ultimately use this sheet steel in their automobiles, refrigerators, implements, office desks, filing cabinets. How interesting it would be to know how this plant was conceived and brought into being, the motives that energized men to undertake such a huge project, the obstacles that stand in the way of the progressive steps.

Only an inkling of the answer to these musings was I able to get from the addresses of R. J. Wysor at the luncheon and Tom M. Girdler at the dinner. Mr. Wysor spoke of this plant as one of the miracles of modern industry, a development that has drawn on the inventive genius of man through the ages, a brain child. "Frankly," he said, "we resisted as long as we dared the construction of this wide strip mill. . . . As to the economic side of the picture, naturally we had hoped that business would be more propitious when the mill was completed. . . . In the social and ethical aspects, we believe you agree with us that progress cannot be resisted."

A little of the philosophy of Tom M. Girdler, whose dynamic personality forced this whole project to completion, has helped me to a little better comprehension of the scheme of things in this industrial enterprise.

"The continuous mill is one single machine. A blast furnace is really one single machine. Steel deals with materials by the ton. We think of land in terms of acres. And in the same way, money for capital investment is figured in the millions.

"This is simply the nature of the business. The making of steel cannot be handled by small companies, because of the enormous size of the production units required to manufacture steel on an economical basis. A company can't turn out pig iron with half a blast furnace, or turn out strip steel with half a mill. If a company attempts to make pig iron in a small old-fashioned furnace, or turn out strip steel on the old small strip mills, its costs run up to such a point that it can no longer compete with the rest of the industry. Size of productive equipment, size of capital investment, and size of company are factors which have gone together in the development of the manufacture of steel on a volume basis, at a price which makes it readily available to the consumer.

"It is a matter of history in the steel industry, just as it is in most other industries, that machinery and equipment make jobs—and the better the equipment, the more jobs that equipment makes in the long run.

"Take this new continuous mill of ours, for instance. This mill, if run at close to capacity, will turn out a million tons of sheet steel a year. The number of men required to run the mill itself represents only a small fraction of the employment made possible by the mill. Every ton of steel going through this mill means that men are employed back in the ore mines, men are employed in the coal mines, men are employed on the steamships and on the railroads, men are employed in the blast furnaces and the open hearths. And every ton of steel that has passed through the mill means employment in the finishing rooms, in the shipping room, and on the ships, trains and trucks that take the steel to the final consumer.

"In view of the present operating rate in the steel industry you may ask the question, 'How is Republic going to keep this mill busy?' In answer to that question I can only say that if Republic had not expected to be able to operate this mill at a high rate of capacity, this mill would never have been built.

"We believe that this mill should mean a great deal to the city of Cleveland. Its location here definitely establishes Cleveland as a more important steel producing city than has been the case in the past. Furthermore, the presence of this mill in Cleveland will, we believe, prove an attraction to manufacturers and fabricators to whom steel is an important raw material, and who may wish to locate their plants close to a ready source of supply. Furthermore, the opening of this mill in Cleveland is important to the city because it lends greater assurance of an added and more stable employment in steel and steel using industries in this locality, when the business picture changes and industrial production can once more get back to normal."

Somewhere back of these statements will be found, I believe, the motivating spirit of nearly all large modern American industrial concerns that have weathered the storm of the depression. Can it be put into such few words as—the desire to gain fitting recognition and just compensation for service to a community in a democratic way?

This indeed was a day to be remembered. And what a day! What a plant! What perfect hosts!

Silica Scale Prevention

Silica scale is at present one of the most troublesome of the water treatment problems. Attention has been focused on it by high temperature, high pressure boiler operation, but it can be and often is a troublesome factor not only in boilers but in cooling systems and heat exchangers as well. This article outlines a control system based on the silica chloride ratio which has been proved by accurate check over a period of many months to be a simple and adequate method of eliminating silica deposits.

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SILICON DIOXIDE has been reported as a constituent of boiler scales almost since the first scale analysis, but its importance as a factor in scale formation has only been recognized recently, although Christie[1] mentioned its occurrence in combination with alumina 30 yr. ago. Christie also noted the presence of a silica factor in low pressure boilers and it may be said that there is no boiler pressure at which silica may not be a factor. Too often, today's commentator on water problems overemphasizes high pressure tendencies, leaving the medium or low pressure operators with a false sense of security.

Silica scale formations may occur in almost any type of water using equipment over a wide temperature range and from atmospheric pressures up to the highest pressures available. Scale formations from silica tend to be hard and heat resistant and are objectionable in any system. Silica is present to some extent in all natural waters occurring in solution as silicic acid or as the alkali salts of silicic acid. It is sometimes present in colloidal suspension bordering on the true solution and, frequently, is present as suspended matter from clay and silt. Almost any of the possible silicon salts may occur in natural waters in solution or suspension and the severity of the silica problem is, naturally, influenced by the form in which it occurs.

Living organisms introduce and complicate the silica problem in many systems and although the diatoms are most frequently mentioned in connection with cooling systems, their presence in wells, reservoirs and ponds often is a factor in silica scale formation in other water systems. Dust pollution of exposed water supplies is a source of silica contamination and western windstorms have introduced silica problems into many a water supply or water using system.[2] Alkaline waters may dissolve silica from sand filters and zeolite softening may increase silica contents.[3]

Consideration of this brief discussion indicates the widespread distribution of silica in water supplies and the difficulty of controlling by external removal such a prolific element. Tray[2] and Sumner[4,5] have discussed these factors in considerable detail along with the increased silica scale forming tendencies of low hardness

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[1]Christie, "Boiler Waters" D. Van Nostrand Co., (1906)

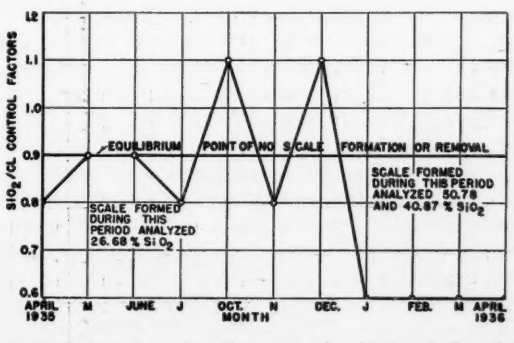


Fig. 1. Scale formation chart from a 750-hp. Sterling boiler. During this period ordinary control methods were used. Figs. 2 and 3 show later periods during which silica chloride control methods were used

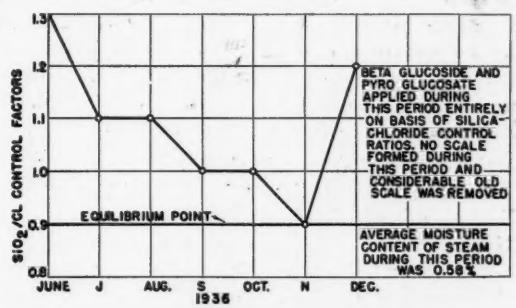


Fig. 2. Scale removal chart for a 7-mo. period when silica chloride control was used exclusively. No new scale was formed, in fact, considerable old scale was removed

waters. Boiler scales containing high percentages of silica may contain the simple calcium or magnesium silicates or the more complex alumino silicates. The use of sodium silicate water treatment introduces the simple type of deposition while sodium aluminate treatment results in the formation of zeolite which may form zeolite scale.[6]

[2]S. E. Tray, "Treatment of Silica for High Pressure Boilers" Power Plant Engineering (Sept. 1936)
[3]Thresh, Beale, Suckling, "The Examination of Waters and Water Supplies". P. Blakiston's Son & Co., Inc. (1933)
[4]R. E. Summers, "Boiler-Water Troubles and Treatment with Special Reference to Problems in Western Oregon" Engineering Experiment Station, Oregon State Agricultural College, (May, 1935).
[5]R. E. Summers, "Some Anomalies of Siliceous Matter in Boiler-Water Chemistry" Combustion (Jan., 1935).
[6]R. E. Hall, "Water Conditioning for High Pressure Steam Generation" Mid-West Power Conference (1936)

Erratic results obtained from efforts to control siliceous deposition may be understood from the number of variables involved. Efforts to control deposition using the phosphates, aluminates and carbonates or hydroxides have failed to develop positive control methods and the absence of such methods interferes materially with their application. Basing control entirely on determined silica content of the boiler water without reference to other equilibria opens the possibility that a low content may be due to silica removal in the process of scale formation and the determination of silica in sludge seems to involve too many variables for application as a control method.

Although organic colloids are widely employed in

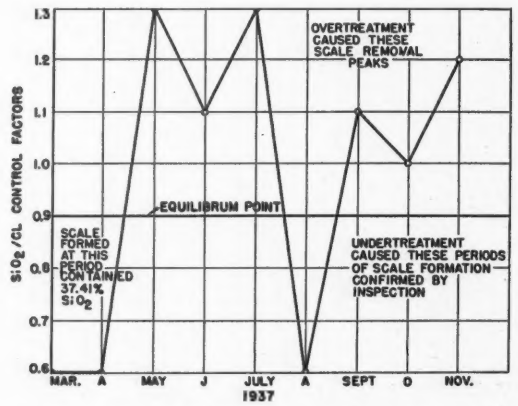


Fig. 3. Alternate scale formation and removal caused by deliberate overtreatment and undertreatment while using silica chloride control

water conditioning and such control methods as the sulphate chloride ratio are firmly established and generally recognized, no satisfactory explanation for their reaction with silica has appeared as indicated by the absence of any positive control method. The use of organic chemicals for scale and corrosion control purposes centers around the glucoside derivatives and it is natural that these chemicals should offer properties of interest in silica control. It is also evident that the application of organic chemicals demands the use of a positive control method such as this article describes.

Control Methods

Beta glucoside and derivatives by substitution or condensation react with silica to form compounds which are stable and soluble at boiler pressures. These compounds remain soluble at room temperatures and this fact is utilized as the basis of control. High alkalinities are totally unnecessary using these reagents and total alkalinities below one hundred parts per million are possible while preventing or removing siliceous depositions. The silica chloride ratio is used as a means of determining the adjustment of treatment required and may be used to determine the presence, absence or removal of silica scale while the boiler is in operation. The principle of application is identical with the use of the sulphate chloride control ratio.

Applying a corrective chemical which maintains silica in solution, the silica in the boiler water should concentrate in direct proportion to any other soluble

I. Table showing the alkalinity range over which satisfactory silica chloride factors were maintained in the plant from which the data for Fig. 1 to 3 were plotted. Equilibrium point for this water was .9; average dissolved solid concentration at the time the determinations were made, was 1500 to 2000 p.p.m. The pH values varied between 10 and 11

Alkalinity	53	44	60	55	70
Silica/chloride factor ...	1.1	0.9	0.9	1.1	0.9
Alkalinity	210	197	167	109	96
Silica/chloride factor ...	1.1	1.1	1.1	1.0	1.0
Alkalinity	277	346	340	304	513
Silica/chloride factor ...	1.1	1.1	1.1	1.0	1.2

constituents. As chlorides are soluble, the silica chloride ratio in the raw water may be used to express the equilibrium point in the boiler water. If the silica ratio drops below the raw water value, it is evident that silica is being removed from solution and scale formation is occuring. If the ratio becomes greater than the raw water value, it is evident that silica is being dissolved and scale is being removed. This ratio has been applied under a variety of conditions and internal inspections have confirmed interpretations in every case.

Three Years Operating Data

One boiler which has been under this control for over 3 yr. may be used to illustrate the effectiveness of this method. In this case a typical siliceous water containing about 10 p.p.m., of silica and 60 to 70 p.p.m., dissolved solids is in use. The boiler referred to is a 750-hp., Stirling operated at 185 lb. ga. pressure. Boiler water concentrations are carried between 1000 and 4000 p.p.m. Load conditions vary up to 250 per cent rating and the boiler has been washed and inspected weekly during this period. This fact is of the greatest importance as it has permitted close correlation of analytical data with internal conditions.

Three charts have been prepared showing the boiler conditions at different periods. Each chart shows the equilibrium point or silica chloride ratio of the raw water. The average monthly silica chloride ratio of the boiler water has been used to indicate the boiler condition which was confirmed by internal inspection. The first chart, Fig. 1, represents the conditions existing while control was based on ordinary control methods such as hardness, sulphate chloride ratios and excess treatment content. During this period the water was

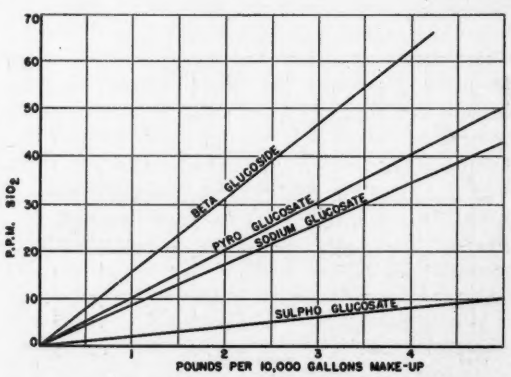


Fig. 4. Quantity of chemicals required for silica scale prevention in boiler operation at from 100 to 400 lb. ga. pressure is a function of the SiO_2 in the makeup

treated at various times with inorganic phosphates and organic chemicals. Practically all of the common organic and inorganic chemicals had previously been applied in this boiler without success.

Examination of this chart shows that although routine control methods indicated satisfactory conditions, erratic results obtained in the boiler with silica deposition occurring 7 mo. out of the 11 recorded, silica removal occurring during 2 mo. and the equilibrium point being held during 2 mo. Theories of cyclic periods of scale formation and removal could easily result from such data in the absence of a specific control method.

The second chart, Fig. 2, represents a 7 mo. period during which silica chloride control ratios were employed exclusively as a control method. No scale formed during this period and considerable old scale was removed. As the water reached the equilibrium point, treatment was increased slightly causing a marked increase in silica chloride ratio.

Figure 3, the third chart, shows alternate periods of scale formation and removal induced by deliberate undertreatment and overtreatment. Efforts to reduce treatment as an economy measure caused the undertreatment periods followed by overtreatment when plant operators attempted to remove depositions disclosed by inspection and predicted by the control test.

These results have been checked in various boilers under a variety of conditions with equivalent results. The silica chloride control ratio in conjunction with glucoside derivatives has proven a positive method of eliminating silica depositions in every case. The application of the silica chloride control ratio does not eliminate the need of additional control determinations to regulate other factors such as corrosion, concentrations and possible sulphate scale. Both the sulphate chloride and silica chloride ratios must be employed to insure freedom from either type of scale. Other control methods for regulating sulphate deposition may be used in conjunction with the silica chloride ratio and, of course, where sodium sulphite or sulpho glucosate is used for oxygen control, the sulphate chloride ratio is valueless.

Alkalinity

Alkalinities carried with glucoside treatment for silica control may be regulated to any desired value with respect to other conditions. As indicated in Table I, alkalinities are not an important factor in obtaining the desired silica chloride factor.

Silica scale may occur in any type of water using equipment and cooling systems of engines and compressors and condensers are often scaled due to silica deposition. Heat exchanger coils in cooling towers are frequently coated with silica formations. Silica depositions increase in severity with temperature increase in common with other scale forming materials but the fact that silica formations may occur at low temperatures is sometimes overlooked. In boiler use, the worst silica waters are generally classed as "soft" with respect to calcium and magnesium contents but in cooling systems such a generality cannot be applied.

The algae factor in cooling system scale formation is an important one and many a silica scale problem has been solved by chlorination to destroy living organisms of the diatom type. All silica deposition in cooling systems is not due to living organisms and silica contents of raw water are usually sufficient to introduce the scale factor. Where this is not true, silica entrainment from dust storms will usually provide sufficient contamination for scale formation.

Exhaust valves of internal combustion engines are particularly liable to silica deposition due to temperature and circulation conditions. Heat exchanger coils also show decided silica scale tendencies and the use of acid treated water for cooling purposes tends to increase siliceous depositions.

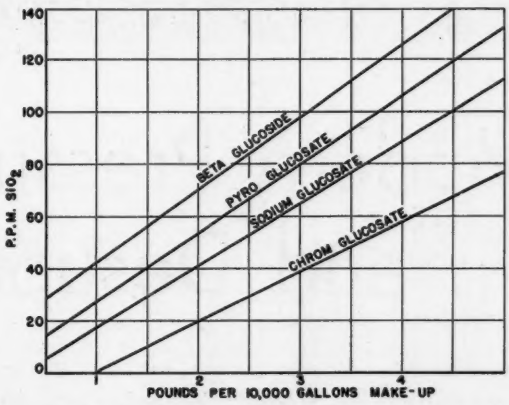


Fig. 5. Quantity of chemical required for silica scale prevention in water for temperatures up to 220 deg. F. The reduction in quantities for lower temperatures is too small for practical consideration

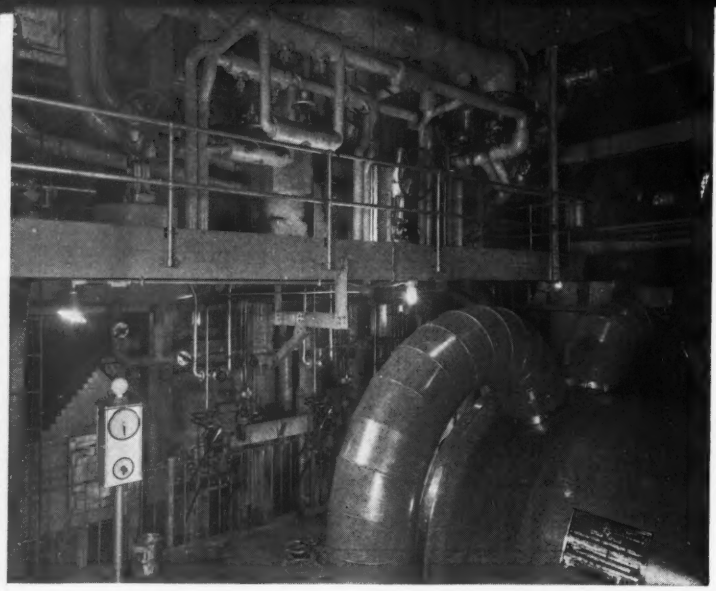
The silica chloride control factor may be used in controlling cooling water tendencies if no external factors interfere with its application. A low factor may be said to positively indicate scale occurring but a high factor may be due to atmospheric contamination and, hence, not necessarily indicate satisfactory conditions. The use of the silica chloride factor in controlling cooling system deposition must be based on consideration of possible variables introduced in the system itself.

Corrosion Protection

In applying organic chemicals, chrom glucosate is usually employed either alone or in combination with other chemicals for correcting corrosive tendencies in cooling systems. Chrom glucosate is one of the few organic chemicals which may be determined quantitatively by a convenient, rapid method and consequently, silica control is often based on the maintenance of a known excess of this chemical in the cooling water.

Chemicals are usually applied to cooling systems intermittently since variable factors in the system prevent application in proportion to "make up." Average conditions may be maintained to advantage by continuous introduction in most cases. Chlorination, hypochlorination and ammoniation are exceptions to this procedure as proportionate introduction is highly desirable with these materials.

(Continued on page 336)



An unusual view of Logan Station showing at the top of the photograph, the desuperheater bypass piping

Part II. If the fundamental equipment and simple layouts in Part I led you to believe that this problem involved only a reducing valve and a spray of water stuck in a pipe take a look at the refinements in control necessary to meet the needs of the newer stations—automatic controls that can be operated manually but which switch back to automatic as soon as you do something wrong—this is one place where you can't even think wrong and get away with it.

By Chester R. Earle, Engineer
Republic Flow Meters Co.
Chicago, Ill.

Modern Pressure Reducing and Desuperheating Practice

TOPPING TURBINE BYPASSES, in some of the central stations, have been designed to meet the demand for unusually high speed of operation accompanied by high capacity. These requirements have been met by the arrangement shown in Fig 4. One of these installations is designed to pass over 1,000,000 lb. of steam per hr., pressure is reduced from 1200 lb. to 260 lb. and temperature from 900 to 600 deg. F. It was designed originally to open wide from fully closed position in ½ sec. if the turbine trips, and it was thought best under such conditions to use two valves, one to open quickly, under the control of a very rugged tripping mechanism, the other to be always maintained by a back-pressure control in position to pass the amount of steam going through the turbine at the moment. Thus the regulating valve would have to move only a slight amount when the steam flow of the turbine was passed to it by the quick-opening valve. The tank type desuperheater was used to insure instant response of the desuperheater and to provide a method of supplying desuperheater water from storage for several minutes in an emergency.

Operating tests of one of these installations have indicated that the actual speed of operation required of these bypasses is much less than they were designed for. This speed is found to be a matter of seconds, rather than of fractions of seconds and at about one-half load, because of the cushioning effect of the piping system and the low-pressure boilers, almost a minute was required after the topping turbine was tripped, for the pressure drop in the low-pressure system to cause the quick-opening valve to open. As soon as the bypass took charge, however, the low side pressure and temperature were maintained constant. In these particular installations, the high pressure boilers are under complete automatic combustion control and the high pressure and temperature were consequently maintained so closely that the ratio control on the desuperheater maintained the low temperature constant, without the need of a temperature controller.

Another method of designing a topping turbine bypass for high pressure, high speed and high capacity is shown in Fig. 5. Several systems of this type are now in successful operation. In some cases two bypasses in parallel are used; in one case, three parallel systems will be used, two of which are now in operation. The interesting feature is the control of the parallel systems

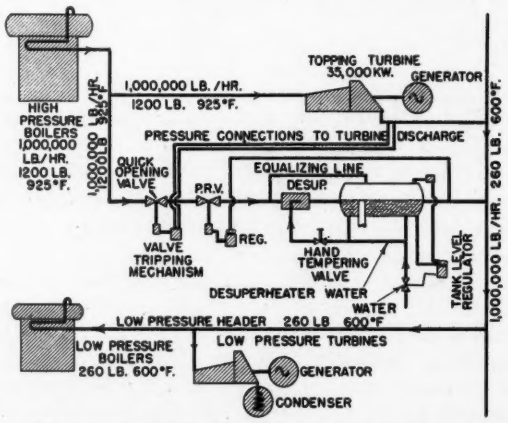


Fig. 4. This is fundamentally the same arrangement shown by Fig. 2 (Part I) but modified to give quick action and large capacity

Because this installation is designed to go into operation almost instantaneously and handle 1,000,000 lb. of steam per hour, two valves were used. The quick opening valve acts only as a stop valve and is closed when the turbine is operating. When the turbine is operating, with no steam flowing through the desuperheater, the regulating valve floats in position to pass the quantity of steam flowing through the turbine, should occasion arise. Water level in the tank is maintained by a separate regulator.

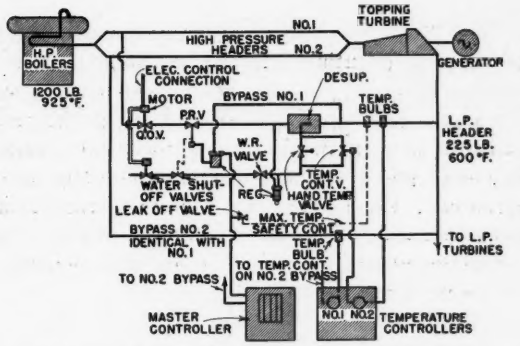


Fig. 5. High capacity can also be provided by using two or more pressure reducing and desuperheating systems in parallel

Only one of the two systems used in this plant is shown in detail as the two are identical. The quick acting valve in this case is motor operated (instead of hydraulically operated as in Fig. 4) and is interlocked with the water shutoff valve. If desired the shutoff valve might have been tied in with the pressure reducing valve as shown dotted. Auxiliary temperature control is also used and if desired the safety temperature control shown dotted could have been added to close the regulating valve by means of a leakoff valve in the control line from the master controller. Flow through the two bypasses can be adjusted or proportioned by means of this master controller.

by a master controller. Because of the type of regulators employed, a master loading can be applied to them so that the parallel systems can carry the same or different proportions of the total load. The master controller functions in exactly the same way it does in a combustion control system; the loading pressure it transmits to the reducing valve regulators can be varied by ratio adjusters. A temperature safety controller bleeds off the loading lines to reduce steam flow if the low temperature goes above a predetermined limit.

Very important is the provision for manual as well as automatic control. When one of these parallel installations is under manual operation, if the high-pressure turbine trips out or the high and low pressures vary beyond predetermined limits, automatic throw-over devices will transfer the bypasses back to automatic control by the master controller. They literally take the control out of the operator's hands in case he is unable for any reason to maintain the required conditions manually. This is a unique installation; when tested under actual operating conditions, the automatic throw-over devices performed their required functions exactly as designed.

In many central stations and industrial plants, control panels for the equipment are installed. These carry instruments for indicating and recording flows, temperatures and pressures of steam flowing to or from reducing valves and desuperheaters. These data may be very important in maintaining the station heat balance; in industrial plants, they also aid in computing steam and power costs for process work.

Figure 5 is unusually interesting in that it shows a number of refinements which have been applied to the fundamental controls discussed in Part I. As a safety precaution, a water shut-off valve in the desuperheater water line can be closed by the reducing valve when that valve closes. Such a water shut-off valve is sometimes built into the reducing valve assembly and is sometimes a separate valve, lever-operated from the reducing valve as shown dotted. In several installations, a motor-operated quick-opening valve ahead of the reducing valve is electrically connected to operate a motor-operated water shut-off valve simultaneously. Again, in cases where pressure reducing and desuperheating stations in parallel are controlled by a master controller, a high temperature safety device operates leak-off valves in the master loading lines leading to the reducing valve regulators, thus changing the steam flow to reduce the high temperature.

Several stations have already installed new units operating at higher pressure and temperature than the old plants but constituting additions, not topping plants. In such cases, there is usually a tie-line to enable the new high-pressure boilers to supplement the low-pressure boilers and in such a tie-line a pressure reducing and desuperheating station is necessary. A typical installation of this type consists of two valves and two desuperheaters in parallel, for a total capacity of 550,000 lb. per hr., reducing from 600 lb. 850 deg. F. to 225 lb. 600 deg. F.

When new boiler units are installed in a station to operate at the same pressure as the old boilers but at a higher temperature, a still different and very interesting problem arises. To solve it, a reversible desuperheater, to be connected as shown in Fig. 6, is being manufactured for one large central station for installation in a cross-over connection between two boiler plants. The old plant supplies steam at 675 lb. 725 deg. F., to turbo-generator units, while two new boilers, supply steam to a new turbo-generator at the same pressure of 675 lb. but at 920 deg. F.

Accordingly, the desuperheater was designed for a maximum flow of 400,000 lb. and a minimum flow of 50,000 lb. per hr. in the normal direction of flow from new to old boilers. This equipment reduces the steam pressure only 7 lb., but brings the temperature from 920 to 725 deg. F. For reverse flow from the old boiler header to the new, this desuperheater will pass a maximum of 200,000 lb. per hr. In addition an auxiliary desuperheater is installed capable of desuperheating a maximum of 50,000 lb. per hr. from 920 to 725. This auxiliary unit

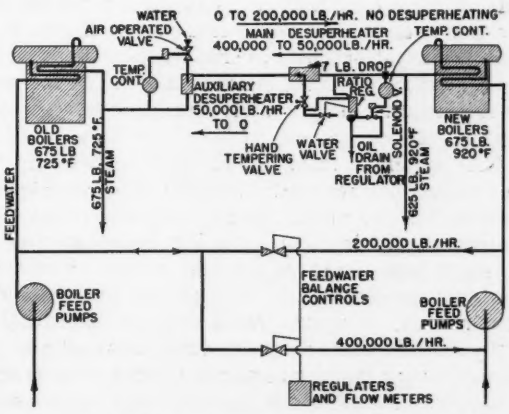


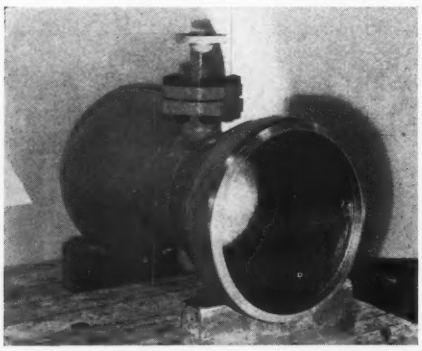
Fig. 6. One of the later developments, a reversible desuperheater now under construction

The auxiliary desuperheater handles low flows up to 50,000 lb. per hr. and acts as an auxiliary temperature control for the main desuperheater for flows of from 50,000 to 400,000 lb. per hr. in the normal direction of flow from the new high temperature system to the older low temperature system. Both systems operate at approximately the same pressure and the pressure drop must be kept low. When the flow reverses, the temperature controller at the right cuts the desuperheater spray out of service. The reversible arrangement involves the control of boiler feed water to the two systems. This is done by the regulator at the bottom which, actuated by steam flow meters, moves to open one feedwater bypass valve and close the other so that each boiler system gets a supply of boiler feedwater proportional to the steam generated.

not only handles low flows but also cuts in automatically to supplement the main desuperheater and to maintain constant steam temperature.

Under normal flow conditions the main desuperheater is controlled by the ratio type control in which a regulator controls the desuperheater spray water by operating a valve in the water line in accordance with the steam flow as measured by the pressure drop across the desuperheater venturi throat, the auxiliary desuperheater, under temperature control, cutting in or out to make the necessary corrections for temperature variations.

In order for steam to flow in the reverse direction, from the old to the new boiler headers, the pressure in the new boiler headers must, of course, be lower than that in the old boiler headers and this pressure reduction will be accompanied by a corresponding temperature reduction. A temperature controller detects this drop and opens a solenoid valve to release the oil pressure from the bottom of the power piston of the ratio regulator. This closes the water valve to shut off the flow of desuperheater water.



Venturi spray type desuperheater built to reduce 600,000 lb. per hr. from 850 to 725 deg. F. It has welding ends and the spray nozzle at the top is removable without disturbing the venturi itself

Related to the foregoing desuperheaters and their controls is the feedwater balance system controlling the flow of water from the boiler feed pumps of each boiler plant. This system consists of regulators and flow meters that control valves in the boiler feed lines and feedwater tie lines to give the required water flow to each boiler plant.

It is apparent from the foregoing comments that the problem of pressure reducing and desuperheating in modern power plants has assumed new proportions. Equipment used in these operations must be rugged to withstand high pressures, must be made of proper materials to withstand high temperatures, must regulate pressures and temperatures accurately and rapidly, must protect against excessive variations and all types of emergency conditions and must possess the greatest reliability.

The foregoing brief review merely outlines the outstanding factors that have caused the long-familiar processes of pressure reducing and desuperheating to take on new aspects and increased importance. It should not be inferred that all the problems have been solved, but sufficient progress has been made to assure power plant designers that the reliability and availability of this equipment are at least comparable with that of the boilers and turbines with which it must serve.

Silica Scale Prevention

(Continued from page 333)

Heat exchanger coils require special methods of introduction due to uneven distribution of water over the coils and daily doses are introduced intermittently employing direct application of the chemical solution to the coil. Hemi phospho glucosate is the chemical generally employed in this manner.

The quantities of organic chemicals required for silica control are shown in Figs. 4 and 5. Figure 5 indicates quantities required for any water temperature up to 220 deg. F. The reduction in quantity effected by lower temperatures is too small for practical consideration.

Silica deposition in hot water systems is uncommon due to the absence of concentration but the use of sodium silicate for corrosion control in these systems has resulted in several cases of silicate scaled piping. Use of improper quantities or disproportionate can easily cause silicate scale in hot water piping.

Silica scale depositions on steam coils used for heating hot water are not uncommon and while this tendency is increased by silicate treatment, such depositions do occur from the normal silica content of the water. The silica chloride control ratio has proven effective in controlling this condition.

Application of chemical control methods is improved by the use of automatic control equipment and the results obtained from chemical treatment are most constant when proportionate introduction of the chemicals is employed. The use of sensitive, flow responsive proportioning equipment is a distinct aid in controlling silica deposition.

Development of the silica chloride control ratio for preventing silica deposition provides a new means of interpreting the water analysis with respect to this factor. Obviously, its use is limited to chemical treatment which maintains the silica in solution or colloidal suspension.

The graphs showing quantities of chemicals required for silica scale prevention list two chemicals, pyro and sodium glucosate, not mentioned in the text. These two chemicals are applied for sulphate scale prevention and pH adjustment and the amounts used for this purpose will also react with the amount of silica indicated reducing the quantity of other chemicals needed for silica control. Hemi phospho glucosate is not shown on the graph because application to heat exchanger coils is more frequently based on physical than chemical factors.

Any of the recognized methods of silica determination may be used in applying this control, but the same method should be used in both the raw water and treated water determinations. While silica determinations have not generally been made in the field, the colorimetric method[7] can be used in field testing as conveniently as other methods now handled by many operators and the application of the silica chloride control ratio will encourage such determinations. Any routine field control test should be supplemented with periodic laboratory analyses as a matter of course.

[7]Schwartz, M. C. "Colorimetric Determination of Silica in Boiler Water" Ind. Eng. Chem., Anal. Ed., 6, 5, 364 (1934).

Midwest Power Conference

Educational Institutions Conduct Meeting In Chicago April 13 To 15

OPERATING under the sponsorship of Armour Institute of Technology, in coöperation with Iowa State College, Purdue University, State University of Iowa, University of Illinois, University of Michigan and the University of Wisconsin, The Midwest Power Conference held its first meeting under this management April 13 to 15, in the La Salle Hotel, Chicago, Ill., with a registered attendance of 410, about equally divided among college professors, technical engineers and power plant operators. The character of the program was somewhat more general than is usual in engineering meetings and a goodly portion of the papers were devoted to trends and developments in the field of power generation and use.

At the opening session C. F. Hirschfeld, speaking on trends of research in the power industry, raised the question as to whether material advances are not being produced faster than they can be assimilated mentally, socially and economically. "Certain it is," he said, "that the true import of our works and their tremendous potentialities for good are frequently and widely misunderstood. It is almost certain that part of the turmoil that characterizes national politics and the economies of the world today has its source in such misunderstandings."

Fuels Session

Ralph A. Sherman spoke of the advances being made in the solution of fuel problems, such as the winning, preparation, distribution and utilization of fuels found in nature. Among the things cited as remaining to be accomplished for a more economical use of fuels are: higher efficiency of utilization for steam generation in the average to small size plants; more complete elimination of smoke and fly ash; and improvements in fuel handling machinery. He believes that competition has been a large factor in the development of more efficient combustion equipment and improvements in the qualities of all kinds of fuel. The advantages and disadvantages of gas, petroleum and coal were compared.

Hope that Illinois coal operators may recover some of the market they have lost to oil was put forth by F. W. Godwin of the Research Foundation at Armour Institute who has been investigating the possibilities of colloidal fuel, a suspension of finely ground coal in oil, which can be stored, pumped and burned, just as oil is burned and in the same equipment. Colloidal fuel, it was stated, using southern Illinois coal, could be offered on the Chicago market at 2.21 cents per therm and with central Illinois coal for 2.26 cents per therm. "If colloidal fuel were to be sold for the 2.76 cents per therm that oil is bringing, the coal producer would receive $5.85 per ton for the finer coal which at present he is glad to sell at from 40 to 70 cents per ton."

Characteristics and use of sewage gas were discussed by W. B. Walhaven based largely upon the results secured in the municipal plant at Springfield, Ill., where, he reports, savings of over $10,000 a year are being made. The gas which is generated from sewage is used to operate two gas engines with a total capacity of 835 hp. continuous operation. This sewage system serves 110,000 people. In usual calculations it is estimated that one continuous horsepower is available from a sewage serving 480 persons. The gas generated at this plant contains 60 to 70 per cent methane, 25 to 35 per cent carbon dioxide and the remaining small portions of oxygen, nitrogen and carbon monoxide. The heat value averages 625 B.t.u. per cu. ft.

Power Plant Developments

At the Thursday morning session, Professor G. A. Hawkins presented a summary of the work being done at Purdue University on High-Pressure Steam, running up to pressures of 3000 lb. and temperatures of 1200 deg. F. He showed the methods and equipment used in the investigations and some of the results obtained as to requirements for circulation in the boiler, materials required for handling steam at such pressures and temperatures and the corroding effect of high-temperature steam on piping. He stated that, so far, results have hardly been sufficiently conclusive to warrant setting up standards for materials or performance.

Speaking on Trends in Industrial Power Plant Practice, Vice President F. H. Rosencrants of Combustion Engineering Co., Inc., set the usual limits for such plants at 1000 lb. pressure and 750 deg. F. total temperature, with process steam bled off at pressure of 150 lb. or less. Initial pressure should be such that exhaust steam is at practically saturation point.

Units of fairly large size, 260 to 660 boiler horsepower are common, with the predominant pressure 400 to 500 lb. in industrial installations of the last 2 yr. Superheat to 100 deg. with header provision for increasing to 300 deg. is common. Bent tube boilers account for 82 per cent of the installations, 40 per cent being for pulverized coal and 43 per cent stokered.

Two-drum boilers are usual for 30,000 lb. per hr. and up with 3 and 4-drum common in sizes ranging above 100,000 lb. per hr. Two-drum type with water-cooled walls has been approximately standardized in design, with firebrick setting and a steel casing.

Possibly pulverized fuel has been used for moderate size plants more than is justifiable, since the stokered plant is less subject to shut down from stoppage of fuel supply on account of the heat reserve in the fuel bed.

In the discussion it was brought out that standby pulverized fuel storage has been used successfully. Also that for wide distribution of heat at high temperatures, a high pressure hot water system may be more economical than a steam system, heating of the water at a central point being more desirable than at several points.

Power Plant Valuation

Papers on Theoretical Considerations by Professor E. B. Kurtz of Iowa State University and on Practical Issues by Professor C. F. Harding of Purdue University treated the subject fully and with a wealth of detail. Professor Kurtz emphasized the importance of life expectancy statistics as well as analysis of the data from which averages have been derived, and illustrated the application of such statistics to the determination of the rate at which reserves should be set aside for replacements.

Professor Harding pointed out the need for taking into account practical experience as to deterioration and obsolescence. He also brought out the difficulty in getting agreement as to the basis for valuation, whether first cost, reproduction cost, or the new "prudent investment" basis, which has not yet been satisfactorily defined. He also showed that in determining rates, which is the reason for most valuations, a small change in the allowed rate of return on valuation will be of much more consequence than a considerable change in the valuation. Also that changes in the market prices of materials, such as copper, brick and steel, during the period that valuation is being made, may largely affect the results, whatever basis is used for making the valuation.

Power Measurements

At the session devoted to power measurements, Royce E. Johnson discussed the calibration of portable standard watt hour meters from the standpoint of three years work and records of the Electrical Standards Laboratory at the University of Wisconsin in calibrating meters from all over Wisconsin. More meters are found to run slow than to run fast and the author felt that the present accuracy standards of plus or minus 0.5 per cent at all loads might well be reduced to plus or minus 0.3 per cent at full load. Contrary to the usual recommendation they have found that lubricating the lower bearing is advantageous and reduces broken bearings although it is a disadvantage in that the meter must be cleaned more often.

The other paper at this session was Measurement of Fluid Flow in Pipe by M. J. Zucrow, consulting engineer of Chicago and long identified with orifice measurement research. His paper was concerned primarily with the practical evaluation of the effect of viscosity on orifice and flow nozzle metering from the standpoint of meter design. For this purpose, Reynolds number a dimensionless constant representing the ratio of the inertia force to viscous force has been found of value. An investigation of 150 meter installations shows a Reynolds of about 500,000 at full capacity to be most common and the author shows how correction curves based on this assumed design value may be used to shorten work of meter design. Much work has been done on the proper evaluation of meter coefficients for the full range of Reynolds Numbers for orifices, flow nozzles and Venturi nozzles but much work remains to be done on investigating the effects of bends, elbows and observations in changing the velocity distribution at the orifice and thus effecting the meter constant.

Power Plant Operation

At the session on power plant operation on Thursday afternoon, M. K. Drewry emphasized the importance of certain factors in high pressure steam plant operation that are relatively unimportant in low pressure operation. One of these, he said, was oxygen in the boiler water. This of course is always important but at high pressure operation he pointed out that even 0.01 cc. of oxygen per liter of water cannot be tolerated since this small amount brings serious corrosion trouble. Another thing to avoid at high pressure, he said is temperature stresses, since the damaging effect of these at high pressures was accentuated.

The problem of steam temperature control at high pressures also is a difficult one and this is intimately related to the relative amount of boiler and superheater surface in modern boilers. There is one boiler on order now whose superheater duty is higher than that of the boiler, in which case the boiler becomes the auxiliary. With such proportions, Mr. Drewry indicated, an increase of only 5 per cent in the duty of the boiler will increase the steam temperature over 100 degrees.

Despite these difficulties, it was made clear that if the effect of the various operating factors were understood and observed high pressure boiler operation was as reliable as low pressure operation. To substantiate that statement, Mr. Drewry pointed out that four 250,000 lb. per hr. boilers had run ¾ of the time for a period of seven years, and that during the time of their operation they provided an availability of 94 per cent.

Two other papers were presented at this session on Power Plant Operation, one on Experiences in Diesel Plant Operation by J. M. Drabelle and the other on Hydro Plant Operation by G. C. Neff. Mr. Drabelle discussed the various factors for and against the Diesel engine in view of his own experiences in the operation of Diesel plants. Among other things which were necessary, he said, was a well paid, well trained, happy group of operators who must possess a good ear for sound and a keen sense of observation.

Special Problems in Power

B.t.u. accounting is an important duty of the engineer and in a paper entitled Heat Energy Costs of B.t.u. Auditing, Professor H. O. Croft of the University of Iowa pointed out the advisability of comparing equipment performance on the basis of energy available for use by the machine rather than on a gross basis which includes heat energy such as condenser losses which are not available for use even by an ideal machine working between the same temperature limits. At the same session Professor A. P. Kratz of the University of Illinois discussed the requirements of air conditioning for residential use.

Readers' Conference

Engineers and Ancestors, Past and Present

THROUGH the hazy mists of the past there glows the steady light of courage, of strength, and of accomplishment of the men who were our forefathers. Engineers of the first degree, these men! They built their homes with such sound materials and workmanship that they've withstood the rigors of 300 yr. of New England winters. And by their indomitable will to succeed, vast lands were surveyed and cleared, towns were planned and built, and our beloved democracy of freedom was established in America.

Who among us, regardless of race, or creed, does not look back through the past upon that little band of Pilgrims with admiration—even awe! They founded their rugged homes along that "stern and rock-bound coast," and in a short generation they hewed their way to freedom, to peace of mind, and to self-determination. In history, in song and story, the names of these adventurous men live on. May their accomplishment lend courage to engineers of every land and every generation—and may their spirit never perish from the earth.

Is there, by chance, hidden away in this story of the landing of the Pilgrims, a bit of philosophy we may have missed? Perhaps it's worth looking into—this tracing of the family tree to those first rugged engineers of field and forest.

Each one of us has two parents, four grandparents, eight great grandparents, sixteen great-great grandparents, and so on back. The adventurous band of Pilgrims sailed in the Mayflower over 300 yr. ago. This takes us back just 12 generations, counting 25 yr. to the generation (as biologists would have us). Thus, taking our own case as present-day individuals enjoying the fruits of endeavor of all who have gone before, we find mathematically that 2 raised to the 12th power carries us back to the landing of the Pilgrims. And, as everybody knows, two to the 12th power is 4096. Therefore, but for intermarriage, we, each one of us, had four thousand ninety-six ancestors living at the time one of these came over in the Mayflower! While one of this number displayed the leadership and fortitude of a Moses, the other 4095 were, perhaps, riding to hounds in Merry Olde England, pitching quoits behind the barn, or maybe just balancing teacups with their neighbors. The courage and stamina of one ancestor who laid the foundations of our present-day democracy contributed definitely to the number of red corpuscles in our blood—to be exact, in the mathematical amount of 1/4096.

"One of my forefathers came over in the Mayflower!" With what glowing pride we make this assertion. But what, exactly, are we doing about it?

For those of us, either within the engineering profession or without, who are inclined to live more by the noble deeds of our forebears rather than by our own individual achievement, there is food for thought here.

One of your ancestors came over in the Mayflower? A forebear of yours helped to clear the land, construct houses, make metal into wrought iron, and accomplish the other thousand and one engineering feats in order to establish the colonies in America? Your direct ancestor fought in the Revolution?

Your responsibility is indeed great. For, because of these things, you cannot rest on the accomplishments of your forefathers.

Yours is the job of "being" an ancestor!

This, it can be said, is even more important than having one.

Waterbury, Conn. L. M. DURYEE.

Draft Losses Through Boilers

IN THE APRIL issue W. F. Schaphorst bemoans the fact that there are no reliable formulas for the computation of draft losses through boilers. He has my heartfelt sympathy, for I have been engaged in a similar search for some time. And I am very much afraid that sympathy is about all that anyone can offer.

Mr. Schaphorst quotes a boiler manufacturer as saying that empirical formulas are used which must be tempered with considerable judgment. Judgment my eye! The fact is that the draft loss through any piece of equipment depends upon three factors; the weight of the fluid flowing, the physical conditions of that fluid, and the geometry of the equipment in question. The evaluation of the first two factors present no major difficulties, and discussions of this evaluation may be found in various reference books. But the third factor represents the "considerable judgment".

The boilers of the various manufacturers, while they may appear quite similar to the casual glance, really differ greatly in detail. The effects of tube arrangement, gas passages, etc., on the draft loss through the boiler are carefully determined, and the results are checked against many field tests. From this a factor which is applicable to each type of boiler manufactured by the company is obtained, and these factors are guarded as jealously as the crown jewels of England. Contrary to Mr. Schaphorst's statement, the boiler companies are able to compute the draft losses through their boilers with considerable accuracy, but anyone else who attempted to do so would find it no mean job.

However, a few crumbs of information have seeped through and become common knowledge. Reynolds, in his investigations of flow through pipes, found that two widely different types of flow existed. He discovered that at low velocities the particles in the stream flowed parallel to each other in stream-line or laminar flow. At greater velocities the flow was found to have a large radial component, which caused motion of the stream particles not only in the main direction of the flow, but also at right angles to it. Reynolds found that the pressure drop of the fluid in the pipe varied instantaneously with the change from laminar to turbulent flow.

The experiments were conducted under conditions that were more or less ideal, and it would be expected that the irregularities of practice would have some effect upon the types of flow. Such proved to be the case. Sharp exit and entrance conditions, flanges, rivets, bends, etc., were found to produce an eddying effect on the laminar flow as well as on the turbulent flow. But after the causes of these eddying effects had been passed a stream which had previously been in a condition of laminar flow, returned to that condition. In other words, the eddying effect was not sufficient to transform a stream from laminar to turbulent flow.

Reynolds found that the quantities which determined the type of flow were given by the expression

$$R = \frac{VDd.}{u}$$

V = velocity of the stream, ft./cu. ft.;
d = density of the fluid, lb./cu. ft.;
D = diameter of the tube, ft.;
u = absolute viscosity of the fluid, lb./ft./hr.

R is known as the Reynolds Number, and when its factors are expressed in consistent units it is dimensionless, or a numeric. When R = 2320, the Reynolds number is said to be at the critical value. Above the critical value only turbulent flow is stable, while below it, laminar flow is stable. With laminar flow the pressure drop is directly proportional to the quantity of fluid flowing through the pipe, whereas with turbulent flow the pressure drop is proportional to the square of this quantity.

Fortunately the values of V and d for the same substance are inversely proportional. This simplifies the computation of the Reynolds Number. If a given weight of material is to pass a given point in a given time, V must double if d is halved. Thus the expression

$$Vd = V_o d_o = W$$

is obtained. V_o and d_o are the values at normal temperature and pressure, and W is the mass flow in lb. per sq. ft. per hr. Reynolds Number can therefore be written

$$R = W\frac{D}{u}$$

Values of the viscosity of the fluids most common in engineering can be found in most handbooks.

For the pressure drop in straight smooth pipes the Fanning equation

$$\frac{dp}{dl} = \frac{fdV^2}{r2g}$$

is the most reliable. In this equation r is the radius of the pipe, and f is the friction factor, which is a function of the Reynolds Number.

E. D. Grimison, in the October 1937 A.S.M.E. Transactions, gives a discussion of an application of Fanning's equation to cross flow of gases. The equation is modified to

$$\Delta P = \frac{fNW^2}{10.84 \times 10^8 d}$$

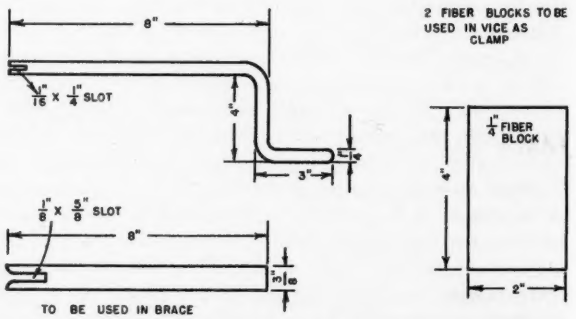
where N is the number of restrictions to flow, and the denominator is a conversion factor including the acceleration of gravity and the change from pounds per square foot to inches of water. Grimison also plots values of the friction factor, f, against various tube arrangements, thus making it fairly easy to compute the draft loss.

I realize that I have not succeeded in supplying Mr. Schaphorst's need for a simple and reliable formula for computing draft losses. Grimison's method is far from simple and uncumbersome, but it is also the most direct and reliable method to date.

Long Island City, N. Y. G. CAMPBELL KOHLAR.

Two Spring Winding Devices

THE CRANK TYPE spring winder can be used to wind springs of various sizes by using round iron of the size spring desired. The straight type winder can be used in a carpenter's brace for winding the larger size spring wire.



Spring winding devices

To use either type winder, place the two fiber blocks in a vise with the wire between them, slightly tighten vise, then place end of wire in the slot and make a couple of turns, now tighten vise to the desired pressure on wire and continue winding. After winder is full, reverse rotation slowly a few turns and pull winder out of spring.

Almost any length spring can be made by using the length and diameter round iron desired. Springs can be cut to any length as needed.

This method has been found to be quicker and more economical than winding in a lathe.

Richmond, Va. E. C. MURRAY.

The Importance of Clean Steam

Do YOUR valve discs wear out quickly? Do you find deposits of scale or dirt in your engine cylinders or turbine blades? Are slugs of water carried over with the steam?

Troubles of this type are common in these days of high steam velocities, high steam temperatures, and high steam pressures. We frequently find deposits of scale or dirt in engine cylinders and on turbine blades. Sodium sulphate, dirt, and calcium carbonate are the principal offenders. Not only do the impurities clog but they cause damage by cutting nozzles, turbine blades and valve discs, making traps and valves inoperable and ruining engine cylinders. Water slugs knock or loosen blades and buckets and cause pounding and vibration.

To avoid these troubles one of the simplest methods is to install a steam purifier, the function of which is the elimination of moisture. By getting rid of the moisture all dirt is eliminated because the water in the steam is what carries over the impurities. Dry steam cannot and therefore does not carry scaling impurities or dirt.

In addition there is a thermal saving. This saving is sometimes small and again it amounts to a worth-while yearly sum. By removing all moisture the steam is more easily superheated. From a heat standpoint, when using superheated steam, one can count on an increase of about 17 deg. to every one per cent of moisture removed.

If you operate a turbine, there will be a reduction in steam turbine water rate of 1 per cent for every 12 deg. increase in superheat. If 2 per cent of moisture is removed the superheat will therefore increase 34 deg., which will be equivalent to almost 3 per cent reduction in turbine water rate. You can easily figure for yourself what this amounts to during an entire year. It may mean that the purifier will actually pay for itself within the first year as an economizing device, and in addition you will get clean steam and protection of equipment.

Newark, N. J. W. F. SCHAPHORST.

Make Up Your Own Steam Balance

THE ARTICLE by Marion S. Bart, with the above title in POWER PLANT ENGINEERING for March, 1938, relates to a subject of much interest, especially to the power plant operator who takes a genuine interest in the job. Unfortunately making up such a balance with any satisfactory degree of accuracy is a much more difficult and involved matter than a casual reading of the article would lead one to expect. To begin with the average industrial plant has a very meager lot of data and such as is available is seldom accurate. More often than not all the data consists in the amount of coal consumed. Usually this record is not kept daily, and, if it is, the figures are estimated from the number of stoker strokes, the number of fillings of a coal bucket or car or some similar approximate method. If the records thus obtained are checked against car load weight, usually some considerable discrepancy will be shown. Other available records, if any, will usually check out in about the same way unless much care is constantly observed to eliminate errors.

Neglecting for the moment probable errors which may in some cases be 10 per cent or more it will be observed that in the example shown in the above mentioned article there are 11 items which, added up, comprise the total steam consumption. It is a fairly safe statement that in no case is a complete steam metering installation provided. If any steam is metered it is generally the total production and possibly the live steam used for building heating or process work. Under these conditions what we then have is an equation for possibly 2 known and 10 unknown quantities. It should be quite clear that the final answer is made up of guesses balanced in accordance with the estimator's experience and ability and may be far from the truth. Even though the distribution may be reasonably correct as to the high pressure steam, in many cases it is desirable to determine what becomes of the exhaust steam. Measurement of exhaust steam is subject to errors of considerable magnitude on account of pressure and quality variation and is not very often attempted as the result is of questionable value.

Probably in most cases the main purpose of a steam balance study is to determine the true cost of power generation with the use of exhaust steam for heating as compared with purchased power, with steam generated in a low pressure heating plant. In this instance there are other factors which render the correct answer even more difficult than has been outlined. In the example shown a figure of 85 per cent is indicated as the amount of winter exhaust steam utilized. This will naturally be largely dependent on the relative magnitudes of the power and heating load, but the percentage mentioned is probably higher than the average in most commercial buildings and it is unsound to use any such figure without very careful investigation. For example, consider an office building. In average winter weather the heating is reduced for a period during the night and early in the morning the temperature is brought up to normal for occupancy. The result is a heavy steam demand at the time the power demand is light. The power demand is usually a maximum in the late afternoon when the heating demand is relatively small. As a result a considerable portion of the exhaust from the power units late in the day will be wasted. Thus if the total heating steam demand during the 24 hr. should approximate the total available exhaust steam from the power units for the same period it would seldom mean a balanced condition approximating complete utilization of the available exhaust. The great variation of heating demand throughout the heating season as well as power requirements seasonable and otherwise, all tend away from the theoretical and desirable balance condition. Another factor seldom considered is that a controlled heating system will save 20 per cent or more over one uncontrolled. Any comparison should take this into account.

Thus it should be apparent that the making up of a steam balance is a complicated and involved study which few plant operators are prepared to undertake.

A further point to consider is that while such a study made in connection with an industrial plant may show a favorable balance, experience indicates that often in industry, growth and modernization of manufacturing processes result in the power demand increasing in greater ratio than the possible use of steam in heating and process work. Therefore, while the aspect may be favorable for the moment, the chances are it will not be so in the future.

Chicago, Ill. A. C. KING.

Air Conditioning Architecture

IN THE PREPARATION of the article under the above title appearing in the April issue, some of the data presented was taken from an article on the same building written by J. H. Walker and published in the October 1937 issue of Heating, Piping and Air Conditioning. Unfortunately, however, proper credit was inadvertantly omitted and apologies are extended for this unintentional breach of courtesy. (Editor)

License Laws

SOME OF the rank and file of my acquaintances who are following engineering, that is the branch consisting of operating steam generating apparatus and prime movers, tell me I am cracked on the subject of license laws and inspection of any and all boilers and pressure vessels containing steam, air, water, gas or oil and the examination as concerns the knowledge of those in charge of operating them, and maybe I am. I have traveled around quite a little and operated quite a lot of different kinds of pressure equipment and during my meanderings have kept watch of things in localities and states where license and inspection laws are in force and where they are not.

The first conclusion arrived at was that, as a whole, in states or locations where there are such laws, the men in charge seemed to have a better understanding of engineering principles and kept the plants in better condition than where there are no laws governing the operation of steam generating and using machinery and their accompanying appliances, although there are exceptions both ways.

With the advent of higher pressures, temperatures and ratings, the situation is becoming more acute and need of trained men and expert inspection of steam equipment with laws governing both are becoming of greater need every day and year. How can any thinking man expect that a plant is going to operate successfully when a large share of the operating forces is untrained, inexperienced and cannot even talk the language of the profession, much less know what it is all about?

Some think that machines must be supplied with oil in such quantities that walls, ceilings, floors and even the air is practically saturated or, if grease is used, that it must be forced into bearings in such quantities that there will be piles of it forced out, and if anything is said about it the always ready answer of "well, oil and grease are cheaper than machinery" is repeated like a child's well learned rhyme, and if there is any mention of license or inspection laws the also ready answer is "well, why should a man need a license when he can do the work?"

Oil and grease are very necessary supplies to any moving machinery but why should they be allowed to get into and remain in a condition where flooding with oil and cramming with grease need be followed to keep things running at all and so far as "doing the work" is concerned, how can a man do the work properly when outside of routine work of oiling he does not know what it is all about or why he is doing it?

For example, the subject of combustion was introduced one day (I was an absolute stranger to the most of the gang) and one who had seen a man taking and making analysis of gas samples, made the noble assertion that "There ain't no man with a bottle and some rubber hose can tell me how to fire no boiler." To appreciate the foregoing statement it should have the full accompaniment of plain cuss words, and this same man, when he had to fire for a time, made tracks on a recording steam gage that looked like an elevation drawing of the teeth of a 6 ft., 2-man cross cut saw. When asked if some of the "teeth" could not be eliminated, made the wise crack that he "didn't see what difference a few pounds up or down made as long as the engine kept rolling and that a piece of paper with some red ink marks on it was all bologna any how."

This is only a sample of thousands of cases in actual existence today. Another was of a fireman who boasted that he could carry 3 in. of draft in the furnace, over the fire using natural draft, or an operator who said the mean effective pressure in an engine he was running was 100 lb. when the boiler pressure was 105 lb. gage and could not seem to comprehend the difference between initial pressure and m.e.p.

How can such men intelligently operate and take care of power equipment and apparatus? My belief is that any man in charge of a plant, whether the chief in charge, assistant chief or watch engineer, should have at least enough technical knowledge of the facts and fundamentals of these things as a whole to be able to explain in an understandable way to some one qualified to pass on it, whether he is competent to be entrusted with the duties required.

My idea is that license laws should be passed and enforced very rigidly. In the interests of safety and economy, for the sake of our own reputations, I believe that every man who is really interested in advancing the profession, as a whole, should use every means in his power to make it something worth while. The title of "engineer" should not be just one of courtesy, bestowed on the individual because he happens to be working in a steam plant. In every place where license laws or supervision of some sort is in force, so far as personal observation goes, the general intelligence and morale of operating forces seems to be above that observed in places where no supervision or no license laws are enforced and the plants are more safely and economically operated.

Duluth, Minn. R. S. FREDRICKSON.

Pump Maintenance Costs Affected by Modern Design

PUMP INSTALLATIONS and pump maintenance problems have been taking on entirely different aspects in recent years. Not only is this true with reference to the pumping of water or other liquids containing acids or other things destructive to materials from which pumps are often made. It is true also with reference to mine dewatering pumps and other pumping installations where the water handled contains solids of a nature known to be erosive, and which therefore wear the working parts of the pump very fast.

One interesting trend of late years is that of incorporating rubber in the working parts of pumps, especially for installations where erosion is a factor to be contended with. In the type of pump employing helical members to produce the pumping action, one helix rolling eccentrically within another, it is highly interesting to note that making one or the other of the helical members of rubber reduces erosion and wear to a remarkable degree. Not only does rubber resist erosion tenaciously, but water forms a natural lubricant for rubber. Doubtless we shall see many developments along this line in the years that lie ahead.

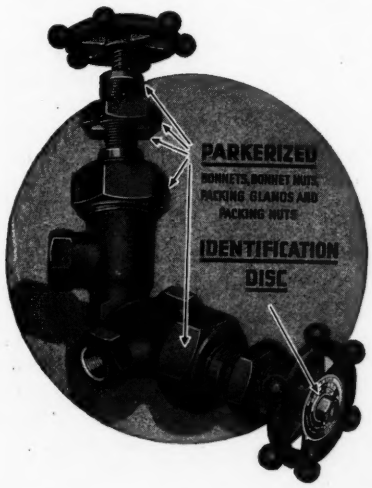
Peoria, Ill. JOHN E. HYLER.

New Equipment

Information that you desire about any equipment will be gladly furnished without obligation. WRITE POWER PLANT ENGINEERING.

Steel Valves with Parkerized Trim

VOGT drop-forged steel valves, made by the Henry Vogt Machine Co., Louisville, Ky., are now available with Parkerized valve bonnets, bonnet nuts, packing glands and packing nuts. This rust-proofing process eliminates galling of threads due to atmospheric corrosion, thereby making it easy to service the valve and maintain high operating efficiency.

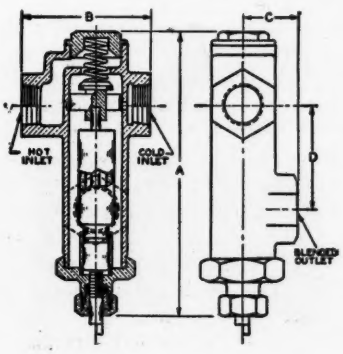


Another feature is the identification disc held in place by the handwheel nut. This disc records the valve size, catalog number, working pressure and temperature, and style of trim, thus making it easy to order proper replacement parts if that should become necessary.

Domestic Water Blender

SARCO COMPANY, Inc., 183 Madison Ave., New York, N. Y., announces the addition to its line of mixing valves, of the type DB Domestic Water Blender having a range of 140 to 180 deg. F., which is designed specifically for use on low pressure heating boilers, equipped with auxiliary hot water heaters of the type in which the heating medium is the water in the boiler.

As the temperature of this water varies with the load on the boiler, the service water may at times be scalding hot. To avoid this dangerous condition, and to provide service water at any desired constant temperature, is the function of the Sarco Blender. One inlet of the valve receives the hot water from the boiler or from a storage tank. Cold water is added through the opposite inlet. The mixed water flows over a Sarco thermostat of the liquid filled type and equipped with packless seal of Sarco helically corrugated tubing.



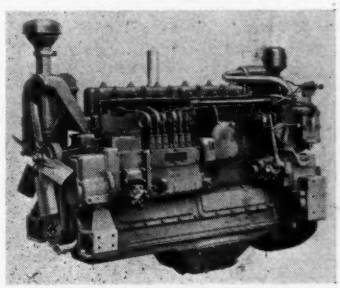
Split-Klozure

THE GARLOCK PACKING CO., Palmyra, N. Y., has just announced a new patented oil seal which is split or cut open and can be easily installed without dismantling the machine. This new product is called the Garlock Split-Klozure. It is made of the same Garlock compound of which the company's other Klozures are made. The compound which is inherently resilient is dense, non-porous and grainless and will not absorb oil and thereby become soft and flabby.

The sealing ring is offered in sizes from 3 to 52 in. in dia. and may be used either on original applications or to replace unit type installations when the renewal of the original seal becomes necessary.

New Diesel Engine

ADDING to its line of industrial Diesel engines Caterpillar Tractor Co., Peoria, Ill., has announced a new, six-cylinder, 66-hp. model, designed as the D4600 and well suited for use in shovels, draglines and hoists, or connected to a generator as an electric power producer. The fuel injection system is similar to that of all Caterpillar Diesels. Both the injection pumps and injection valves are set at the factory, and require no field adjustment.

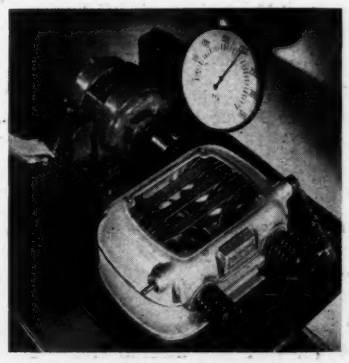


As a source of electric current, it will be offered as a unit with a 35-kw. generator at 50 cycles at 1500 r.p.m.; or as a 32½-kw. generator at 60 cycles at 1200 r.p.m.

A 14-hp., two-cylinder gasoline starting engine is mounted at the rear of the Diesel, directly over the flywheel housing, having a governed speed of 3000 r.p.m. This engine cranks the Diesel through a pinion and clutch arrangement which automatically disengages when the larger engine fires. The starting engine offers a positive starting method under all climatic conditions. For indoor installations, where the atmospheric temperature is more or less constant, electrical starting is available.

Vari-Pitch Speed Changer

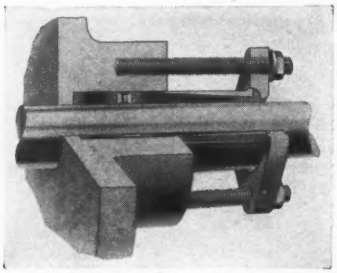
THE TEXROPE DIVISION, Allis-Chalmers Mfg. Co., Milwaukee, Wis., announces a new speed changer consisting of a ruggedly constructed compact unit applicable to all manner of industry. It utilizes the principle of that company's multi-groove Vari-Pitch sheaves. Designed with double shaft extensions and driven from a standard motor, this totally enclosed unit provides the flexibility that makes it adaptable to a wide variety of layouts to suit the individual application. Where the change in speed is to be adjusted manually only, the



unit is provided with a readily accessible hand wheel control, however, the unit can be equipped for electric remote control or manual remote control if desired. The present range of capacities now being offered includes ratings up to 33 hp. with ratios as high as 3¾ to 1.

Conical Self-Aligning Packing Glands

THE CRANE PACKING CO., 1800 Cuyler Ave., Chicago, Ill., is offering a new type conical, self-aligning packing gland adapted for use on both the steam and liquid ends of pumps, and the power and compression ends of gas compressors handling cracking coil gases, still gases, butane, propane, natural gas, ammonia; also in pumps handling asphalt, tar, sludge, tank bottoms,

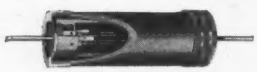


liquid propane, butane. It has likewise built up an outstanding record on reciprocating pumps on bottom service, distillate service, reflux service, flash corrector service, high pressure gas compressors, and other refinery services where high pressures and temperatures create packing problems.

The gland cup is made from nickel steel and fine bearing bronze, machine finished inside and out. When installed, it is packed with "John Crane" Super-Seal split packing inserts moulded to fit the gland. The inner surface of the cup is tapered, the effect of which is to force the packing around the rod with each stroke of the piston, instead of merely compressing it in the gland and stuffing box. Leakage and blowby are eliminated, even when machines are idle, and, using "John Crane" split packing inserts, a maintenance man can repack the gland in a few minutes. The ball and socket construction compensates for "float," present in varying degrees in pumps and compressors, and prevents wedging or distortion of the cup where it meets the cast-steel follower, if the studs are drawn up unequally when the gland is being adjusted.

"Air Cooled" Fuse

TO PREVENT undue heating of renewable fuse cases Pierce Renewable Fuses, Inc., have developed a new screen-vented, air-cooled fuse. Both ends of the fuse case have a series of small holes through which



the air circulates. As an additional safeguard to prevent flames from escaping in case of a blow, both ends of the fuse are also equipped with a series of fine mesh screens through which the air must pass.

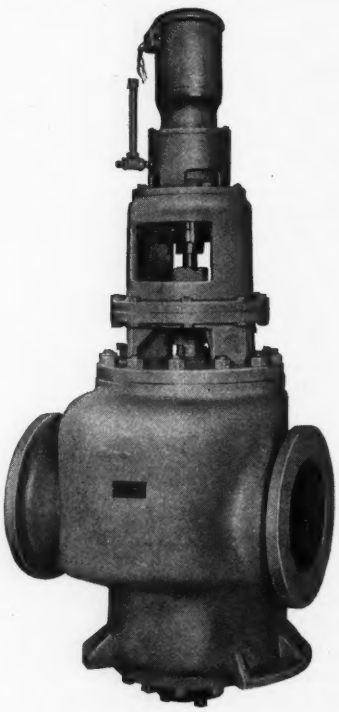
In a series of tests made on these fuses under actual load conditions, it was found that these fuses operated from 5 to 40 per cent cooler.

Another important advantage offered in Pierce Renewable Fuses is the simplicity of design—there are only 2 parts and the link.

Pierce Renewable Fuses, Inc., have just published a new folder on their air-cooled fuse. It also contains a valuable chart showing how different size motors should be fused for best protection and service. Copies of this folder may be secured by mailing a request direct to Pierce Renewable Fuses, Inc., Buffalo, New York.

Self-Cleaning Strainer

APPLICABLE and preferable where a relatively large quantity of fine dirt, sand, etc., is to be removed from water which has already passed through a traveling screen or conventional twin or single strainer, the Elliott Type K strainer is automatically cleaned by a continuous back-flushing of the straining element. This action is ingeniously obtained by building the straining element of a series of strain-



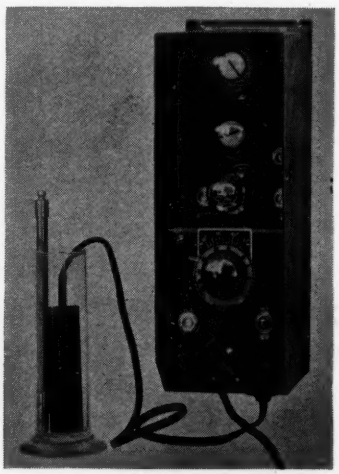
ing cartridges, which fit in channels in a slotted, brass cage. A rotating element is slowly turned by a geared electric motor, and straining cartridges are blanked off one by one and back-flushed by a portion of the strained water.

The body of the Type K self-cleaning strainer is cylindrical and of cast-iron construction with flanged inlet and outlet nozzles on the same horizontal centerline. The slotted cage or basket, made of brass, fits into machined seats in the strainer body at top and bottom. The straining cartridges are made of alternate layers of flat and corrugated copper strips securely fastened together. These cartridges are inserted in the slots between the basket ribs and can be pulled out for inspection without removing the cage or basket.

It is available in sizes from 4 in. to 24 in. for pressures from 25 to 125 lb. gage. Elliott Co., Jeannette, Pa.

Nalco Blinker

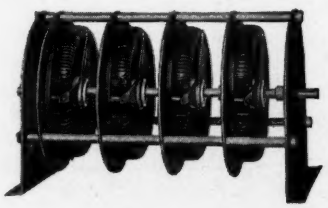
THE NALCO BLINKER is an instrument which acts as a continuous indicator of correct solids content in condensate, steam, feed or boiler water, and for checking the quantity of dissolved solids in any water containing from 1 p.p.m. to 700 grains per gal. (12,000 p.p.m. approximately).



The most popular use of the Blinker is continuously to check the solids in the main steam header and thus insure pure steam at all times. This is done by taking a continuous sample of steam through a cooling coil and reducing to a temperature below 100 deg. F. The condensed steam is then passed through an electrode connected by wires to a Blinker which may be in any convenient location, such as engineer's office, laboratory, boiler room, etc. Any water, such as blowdown, feedwater or condensate may be checked in the same manner. National Aluminate Corp., 6216 West 66th Place, Chicago, Ill.

New Ohmite Rheostat Tandem Assembly

A SPECIAL TYPE of tandem construction and assembly has been designed by Ohmite Engineers for special use with the larger-size Ohmite Rheostats. This assembly, like the standard Ohmite tandem assemblies, is used for the control of electrical apparatus where several circuits are to be simultaneously varied, as in the control of the individual phases of a 3-phase line, etc.



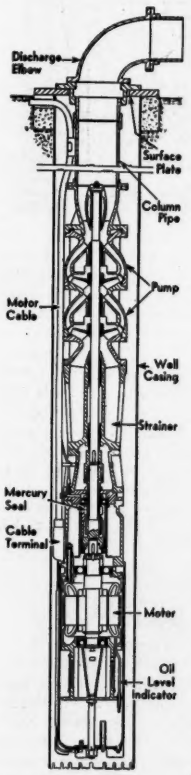
A four-unit assembly recently completed consists of four Ohmite Model U Rheostats rated at 1000 watts each. The overall length is approximately 3 ft. 2 in. and the height 15⅛ in. The rheostats are 12 in. in diameter, and the assembly has a ¾ in. through shaft. This assembly is intended for motor drive, is equipped with separate bearings on the end plates, and is mounted on a rigid cadmium plated steel framework.

Each rheostat is individually driven from the shaft through specially made Ohmite Universal couplings, designed to eliminate all lost motion—the contacts thus remaining in perfect alignment.

This special construction and assembly can be supplied for 2, 3, 4 or more rheostats in tandem, using any combination of Model N (300 watt), Model R (500 watt), or Model U (1000 watt) units. Standard-type tandem assemblies are available for use with all Ohmite Rheostat models from 25 to 1000 watts, or with Ohmite Tap Switches.

Ohmite Mfg. Co., 4835 Flournoy St., Chicago, Ill.

Submersible Pump



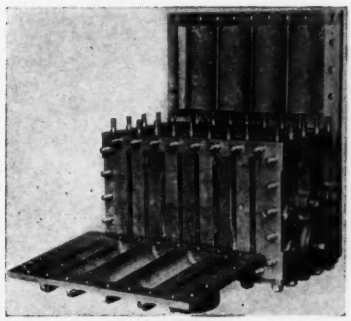
AFTER 8 YR. of successful performance under a wide range of operating conditions, the Submersible deepwell turbine pump has been placed on the market by Byron Jackson Co. of Los Angeles, Calif. This radical departure from the accustomed type of deepwell turbine pump has its motor below, and not above, the turbine bowls. The propelling shaft is very short and the unusually long, small-diameter motor operates submerged at all times in the well water. However, the liquid pumped does not come in contact with the electrical parts or motor bearings, as these are enclosed in an oil-filled case with a mercury seal where the shaft passes through at the top.

The turbine and the submersible motor form a compact unit that is attached to and supported by the discharge pipe. A submarine armored cable and a small copper oil tube, form the only connection (aside from the discharge pipe) between the pumping unit and the surface of the ground. The Submersible operates equally well and without frequent attention, in deep or shallow wells, crooked or straight wells, sumps or natural bodies of water.

The motor is a squirrel cage induction type and its rotor is carried on two ball bearings, one of which is a radial thrust to take both the small weight of the rotary parts and the hydraulic load, the other is of radial type and its chief function is to center the rotor. Water is sealed out at the top by mercury in a rotating cup that is attached to the motor shaft.

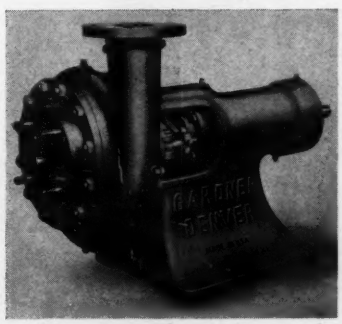
Ribbon Counterflow Exchanger and Cooler

THIS EXCHANGER or cooler has narrow, flat passageways for both liquids, arranged for true counterflow heat transfer. There are no gasketed joints which could permit leakage between fluids, resulting in contamination. All passageway or transfer surfaces are accessible for cleaning. The passageways for one liquid can be opened for cleaning by removing two heads, without shutting off the flow of liquid through the other passes. Passageways are streamlined to reduce turbulence and friction losses. The passageways are thin, causing intimate contact between all particles of the liquid and the heat transfer surface. This gives a very high heat transfer rate and performance tests, liquid to liquid, with clean surfaces gave heat transfer rates of over 500 B.t.u. per sq. ft. per deg. F. Condenser Service & Engineering Co., 310 Twelfth St., Hoboken, N. J.



Non-Clogging Centrifugal Pumps

THE GARDNER-DENVER CO., Quincy, Ill., announces the Types J and K non-clogging centrifugal pumps, adapted for handling industrial wastes, process fluids, food products and raw unscreened sewage; in fact, to all industrial fields and manufacturing processes requiring the handling of liquids in which quantities of solids are held in suspension. These pumps are built for either horizontal and vertical dry pit installations. A complete line of the necessary accessories for the vertical installations is also furnished, including shafting, guide bearings, compression and flexible couplings.



The impeller, of the side suction enclosed type, is made of hard close grained alloyed cast iron with two streamlined blades, rounded to prevent catching stringy or fiberous material and proportioned to permit the passage of solids without clogging. The casing is made of alloyed cast iron, symmetrical so that it can be used for both right and left hand pumps and the discharge nozzle can be placed in any one of eight positions.

The stuffing box is a separate casting bolted directly to the casing and is extra deep to receive a minimum of six rings of packing. A water seal ring is provided with tapped opening for connection to clear water when handling abrasive materials.

Additional features include: heavy duty double row grease lubricated ball bearings contained in dust and splash proof housings, disc or flat type renewable double wearing rings. The clean out elbow is provided with a plug having the same contour as the elbow.

The mechanical construction of the J and K pumps is identical except that the frame of the Type J pump has a foot cast integral with it and the Type K pump has the foot or base bolted on the suction side of the volute.

Rotameter Flow Gage

MADE by Fischer & Porter Co., 110 W. Penn St., Germantown, Philadelphia, Pa., the new Universal type of rotameter flow gage is compact, neat, simple and inexpensive. The tapered Pyrex tube is mounted in a polished brass case which protects it against external damage. The bright red flow graduations are viewed through an ample slot.

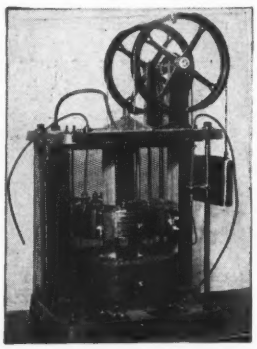
Knurled nuts at each end of the case hold the end pieces in position. These have both vertical and horizontal connections. By loosening the knurled nuts the end pieces can be swiveled about to make the horizontal connection face in any desired direction. The ball indicator float drops out when one of the knurled nuts is unscrewed. The height of the ball in the tube shows the rate of flow, and instruments of any capacity from a pint a day to 50 gallons per minute are made for liquids and gases. All sizes equipped with precision-bore interchangeable tubes.

Station-Type Constant Current Regulators

Two new station type constant current regulators are announced by the Westinghouse Electric & Mfg. Co. Type RS, non-automatic, is designed to operate in an indoor substation with a manually operated control panel. This type will regulate from full load to no load within one per cent, plus or minus, of rated secondary current when operated at rated primary voltage and frequency and on unity power factor load.

The middle leg of the core is surrounded by the primary and secondary coils. The upper or moving coil is counterbalanced by a weight supported by flexible chains running over a pair of wheels mounted on ball-bearings.

The coils are made up of concentric windings separated from each other by spacers so as to expose each side of each section to the circulating air, thus reducing the operating temperature of the windings and eliminating "hot spots."



The second, Type RZ fully automatic constant current regulator is designed primarily for use in an unattended substation. However, due to its many advantages over the non-automatic type it can be advantageously used for any indoor installation. These regulators may be controlled by either a RCOC switch or a time switch, the same as a pole-type regulator.

The fully automatic station-type regulator is similar in appearance to the non-automatic station-type regulator, while the electrical characteristics are essentially the same as the pole-type regulator. These regulators are the air cooled type, no oil being required except a small amount in the dashpot for dampening purposes.

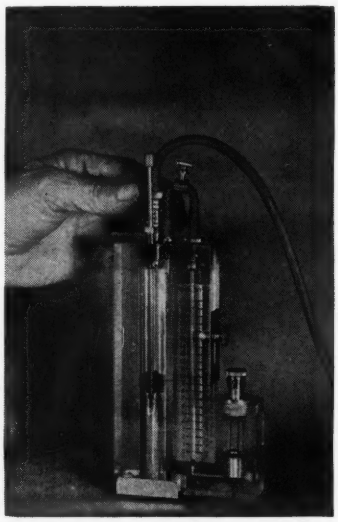
The fully automatic regulator has a higher inherent reactance than the non-automatic and, therefore, under practically any condition of load it gives much better protection to series lamps. The machine is so designed that it can be started automatically with the coils together and with only one lamp on the circuit, regardless of the capacity of the transformer. The current surge, being small, will not be sufficient to destroy the lamp.

The RZ regulators are provided with the same primary and secondary taps as for the Type RS and the same reduced load connections for improved performance may be employed.

CO_2 Analyzer

THE NEW Dwyer Pocket CO_2 Indicator, complete with carrying case and all accessories, weighs less than 3 lb. and can safely be carried in the pocket.

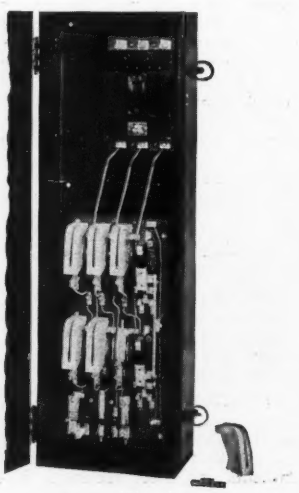
Operation of the indicator is simple, and accurate results are easily obtained. Tests are made while the indicator is held in the hand or in the clip which is provided in the carrying case. The gas sample is pumped in with a dozen strokes of the aspirator bulb while a plunger is held down. The reading is then taken from the mercury column after the absorbing unit has been raised and lowered. Mistakes are eliminated by the almost foolproof simplicity.



The body of the instrument is made from a new product of the plastics industry which is perfectly clear and colorless, and unaffected by the caustic solution used in the indicator. This is cut from a solid block with all the bores drilled and accurately reamed to size. One important point that is quickly noted is the entire absence of glass in the construction of this CO_2 indicator which is the product of the F. W. Dwyer Mfg. Co., 565 W. Washington St., Chicago, Ill.

Magnetic Reversing Switches

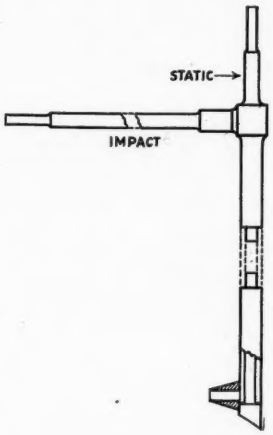
THE OUTSTANDING advantages of combination reversing magnetic switches which employ air circuit breakers have resulted in the development, by General Electric's Industrial Department, of a new line of such devices. This line, which was designed as alternative equipment for fused motor-circuit switches, has such features as low installation cost, space economy, and increased safety. The new combination reversing switches are primarily intended for the full-voltage starting of a-c motors.



The equipment is particularly suitable for use where short-circuit protection for individual motors is desirable and as a means of disconnecting the power-supply line to switch and motor. The complete device consists of an air circuit breaker, two magnetic contactors mechanically interlocked, and a temperature overload relay, all enclosed in a sheet metal case for wall mounting. The enclosing case is designed to permit operation of the air circuit breaker while the cover is shut. In addition, the device offers the advantage of low maintenance because the breaker can be readily reclosed after it has tripped on short-circuit.

Straight Stem Pitot Tube

DESIGNED by Lewis M. Ellison for use in thick wall ducts in which the angle type cannot be conveniently inserted, the straight stem pitot tube is made by the



Ellison Draft Gage Co., 214 West Kinzie St., Chicago, Ill. The outer tube is 5/16 in. o.d., the flow end of which is machined at an angle of 59 deg. transmitting a true static pressure through the ⅛-in. inner tube when faced at right angles to the flow. By means of a conical tip, facing the flow, a true impact pressure is transmitted through the outer tube.

Four-Cylinder Diesel

THE MURPHY DIESEL CO., Milwaukee, Wis., announces that their 4-cylinder engine is now ready for delivery. This machine develops 100 hp. on continuous load and is similar to the 6-cylinder Murphy design. Like the 6-cylinder engine, a single control wheel acts as a throttle as well as operating a simple gasoline starting mechanism. There are no outside fuel lines or lubrication pipe lines, and complete safety is insured as the engine stops immediately if oil pressure fails for any reason. Each cylinder is provided with completely independent injection unit mounted at the center of the cylinder head and driven directly by overhead camshafts. Fuel is filtered and supplied at low pressure and metering is accomplished by the fuel injector. Each injector is a complete, independent and interchangeable unit and can be removed and replaced in three minutes time.

News from the Field

CINCINNATI GAS & ELECTRIC Co. has elected A. C. Moorhaus acting general manager, and C. G. Eichelberger, assistant to the president, to vice-presidencies. W. R. Freeman has been appointed purchasing agent.

CONESTOGA TRANSMISSION Co., Lancaster, Pa., was recently sold to Pennsylvania Power & Light Co., Allentown, Pa. Included was a 14-mile transmission line from the Holtwood generating plant of Pennsylvania Water & Power Co. to Engleside substation site of Pennsylvania Power & Light near Lancaster.

ARKANSAS POWER & LIGHT Co. is build- a $60,000 transmission line across the Mississippi River at Leland Neck, west of Lake Village, Ark. The line will be suspended between two 560-foot towers weighing 130.000 pounds and 6,000 feet apart. This improvement will permit an interchange of power with the Mississippi Power & Light Co. system.

HORACE J. SNEDEN, 58, superintendent of plants for the Indianapolis Power & Light Co., died at a hospital March 18. Previous to coming to Indianapolis in 1927, he was with General Electric Co. at Lynn, Mass. He belonged to and was director of the Indiana division of the American Society of Mechanical Engineers.

SMOKE PREVENTION ASSOCIATION will hold its 1938 convention May 17 to 20 at Hotel Andrew Jackson, Nashville, Tenn. Exhibit of stokers, boilers and fuels has been arranged by President William Culbert, smoke inspector of Nashville. Frank A. Chambers, smoke inspector of Chicago, secretary of the Association, announces papers on: National Board and the Smoke Prevention Association by a member of the National Board of Boiler and Pressure Vessel Inspectors Association; Responsibility for Smoke and Air Pollution by K. C. Richmond; New Features in Smoke Regulation by R. R. Tucker, smoke commissioner of St. Louis; Aids in Smoke Prevention by Charles H. Schroeder; Residential Underfeed Stoker by E. R. Kaiser, Battelle Memorial Institute.

SULLIVAN MACHINERY Co. has moved its general offices to Michigan City, Ind., but will retain Chicago sales office at 307 No. Michigan Ave.

AT THE ANNUAL meeting of Revere Copper and Brass Inc., Rollo E. Falk, Vice President and General Manufacturing Manager, of the New York office, was elected a director. Mr. Falk has been manufacturing manager since 1932, and previously was works manager of the Dallas division, in Chicago.

R. S. SMITH, former vice president of the Houston (Tex.) Lighting & Power Co., has been succeeded by R. E. Lee, acting auditor of the company. T. H. Wharton has been appointed auditor.

R. D. FINNELL was appointed plant engineer for the new Ripley station of the Kansas Gas & Electric Co. by W. P. Daugherty, power superintendent. He had been engineer of the Neosho plant.

BRADSHAW & COMPANY, 530 Fourth Avenue, Pittsburgh, has been appointed by Forty-Eight Insulations, Inc., as its representative in the Pittsburgh territory for a line of efficient heat insulations widely used in power plants, oil refineries and industrial plants for temperature conditions to 2000 deg. F.

AMERICAN SOCIETY of Heating and Ventilating Engineers has announced its 1938 program of research, which lays renewed emphasis on the need for more highly organized and coordinated studies of the physiological aspects of air conditioning. W. L. Fleisher, chairman of the Society's Committee on Research has outlined a long-range study designed to widen the industry's existing knowledge of problems which it is felt are becoming more and more vital to the progress of air conditioning.

IN ORDER TO stimulate the study of arc welding the James F. Lincoln Arc Welding Foundation has announced an Award Program totaling $200,000 in prizes for the best papers submitted on the general subject of arc welding. A total of 446 prizes are offered with a grand prize of $13,700. The papers are classified according to industry and the contest is open to any who have actually participated in the work upon which the subject matter of the paper is based. The contest closes, June 1, 1938. Further information regarding the program can be obtained from the James F. Lincoln Arc Welding Foundation, P. O. Box 5728, Cleveland, O.

AIR CONDITIONING SUPPLY Co. has moved to larger quarters at 4060 Superior Ave., Cleveland, Ohio.

JOSEPH T. ELLIS has been appointed manager of the Oil Heating Division of the National Radiator Corp., Johnstown, Pa., and will continue as manager of the Steel Boiler Division.

DR. H. W. GILLETT, Chief Technical Advisor, Battelle Memorial Institute, Columbus, Ohio, has been chosen to deliver the 1939 Howe Memorial Lecture of the American Institute of Mining and Metallurgical Engineers. The Howe Lecture, established in 1923 in memory of Henry Marion Howe, Past President of the AIME, is given each year by someone of recognized outstanding achievement in iron and steel metallurgy or metallography. The choice is made by the Board of Directors upon recommendation of the Iron and Steel Division.

W. H. & L. D. BETZ of Philadelphia, Pa., announce that J. J. McGuire, chemical engineer, who has been on the technical staff for several years, has been appointed to the position of Assistant Technical Director; George Bernauer, chemical engineer, has resigned his position with the Milwaukee Sewage Disposal Project, and is now associated with this company in its Technical Department. His special field will be sewage and waste disposal systems for municipalities and industrial plants; William Gunmere, chemical engineer, formerly with The American Smelting & Refining Co., Baltimore, has been added to the Technical Staff to do special service and plant study work.

THE NEW YORK BELTING & PACKING Co. announces that it has appointed the Boykin Tool & Supply Co. of Atlanta, Georgia, as distributor of its products in the Atlanta territory.

NEW APPOINTMENTS of sales representatives have recently been announced by the Republic Flow Meters Co., as follows: M. N. Dannenbaum Co. with offices in the Petroleum Building, Houston, Texas, as sales representative throughout the oil and industrial centers of Southern Texas, to handle the complete line of Republic instruments and Smoot automatic control equipment. Cowles & Co., with offices in the Mercantile Building, Dallas, Texas, will render a similar sales and engineering service throughout Northern Texas.

NORTON COMPANY, Worcester, Mass., is planning the erection of a new four-story building 333 ft. by 60 ft. It is to replace Plant One, 53 yr. old, and the old office building. Total floor area will be 100,000 sq. ft. The floors are designed to carry a live load of 250 lb. per sq. ft. The structure of steel and brick will cost $263,000, including four stories and basement. The architect is G. Adolph Johnson and the contractor E. J. Cross Co., both of Worcester, Mass. This is the second step in a renovation and replacement program in which Plant Three was replaced by a new building in 1937.

A. C. MOORHAUS, acting general manager of the Cincinnati Gas & Electric Co., and C. G. Eichelberger, formerly assistant to the president, have been named to the board of directors of the company. W. R. Freeman has been appointed purchasing agent.

CHARLES CROZIER, Battle Creek, and C. W. Spain, Detroit, were recently appointed to the Michigan Electric Administrative Board by Gov. Frank Murphy.

L. L. RAY recently joined the staff of the Duke Power Co. as agricultural engineer for North Carolina. In this capacity, an innovation with power companies, he will counsel with and assist rural customers, individually and in groups, in applying electric service to their respective operations.

ENGINEERS COUNCIL for Professional Development in its fifth annual report emphasizes the value of the "engineering method" of scientific approach in solving economic and social problems and the need for engineers to obtain a good understanding of how to deal with men and with executive problems in order to fit himself for his proper place in managerial, administrative and community leadership.

REVERSIBLE ratchet wrench for ½ in. square drive socket with 15-in. handle that can be shortened to 10-in. is offered by Bonney Forge & Tool Wks., Allentown, Pa.

EXPANSION of its stoker line by the acquisition of patent and sales rights to the Super-Stoker, with complete responsibility for engineering, research and design on this anthracite burner, which has heretofore been manufactured by the John Wood Manufacturing Co., also that a new model anthracite stoker is to appear in the near future, with modern improvements, is announced by Link-Belt Co., Stoker Division, 2045 W. Hunting Park Ave., Philadelphia, Penn.

NATIONAL ALUMINATE CORP., Chicago, Ill., announces the appointment of W. O. Widener as exclusive representative in the Southeastern States which includes Virginia, Florida, most of North Carolina, South Carolina and Eastern Georgia. Mr. Widener, who has had 10 yr. experience in power plant work, attended the University of Nebraska for three years, leaving in his Junior year to enter the World War.

AT THE ANNUAL MEETING of stockholders of Johns-Manville Corp., directors elected for the ensuing year included: Walter H. Aldridge, Francis D. Bartow, Lewis H. Brown, H. Edward Manville, William R. Seigle, Enders M. Voorhees, George Whitney and E. T. Stannard.

Alfred P. Sloan, Jr., who has served for 9 yr. as a Johns-Manville director, and Clarence M. Woolley, who had been a director for the past 8 yr., requested that their names not be submitted to the stockholders for reelection because of the pressure of other duties. E. T. Stannard, who replaces Mr. Sloan as a J-M director, is president and a director of Kennecott Copper Corp. He graduated from Sheffield Scientific School, Yale University, in 1905. It was announced that the place on the board left vacant by Mr. Woolley will be filled at some later meeting of the company's directors.

BECAUSE of the increasing interest in the need of research and standardization work on important problems in the field of radiographic testing, the A. S. T. M. has organized a new committee designated as E-7 on Radiographic Testing. This committee will be under the leadership of Dr. H. H. Lester, Watertown Arsenal, and the work at present is being carried on by six subcommittees with a total of some 43 members.

FRANK R. PHILLIPS, president of the Duquesne Light Co., has announced the election of Edmund C. Stone as vice president and general manager of the Duquesne Light Co., to succeed Edward W. Judy, who died on March 24. Mr. Stone, who was formerly assistant to the president of the Philadelphia Co., has a record of many years service with the Duquesne Light Co., having been first employed in 1911 as engineer of cable operations. He had previously been graduated from Harvard in 1904, and served as a transformer design engineer with the Westinghouse Elec. & Mfg. Co. He was successively system operator, assistant to the general manager, planning engineer, and system development manager of the Duquesne Light Co., becoming assistant to the president of the Philadelphia Co. in 1931.

Walter G. Jens, formerly operating manager, has been elected vice-president in charge of operations for the Duquesne Light Co. After being graduated from Armour Institute of Technology, he was employed as an engineer with various Standard Gas & Electric Co. properties. He was then engaged in construction work, coming to Pittsburgh in 1926 as superintendent of construction, and in 1927 was made operating manager of the Duquesne Light Co.

THE STEEL AND TUBE DIVISION of The Timken Roller Bearing Co., Canton, O., has appointed Joseph T. Ryerson & Son, Inc., to warehouse Timken Mechanical Tubing in territories served by Boston, Jersey City, Philadelphia, Buffalo, Cincinnati, Chicago, St. Louis, Cleveland, Detroit and Milwaukee.

JOHN C. CAMPBELL, president of the Newark Wire Cloth Co., died March 18 at his home in Newark, N. J., after a short illness. He was 78 yr. of age. Mr. Campbell was in the wire cloth industry more than 60 yr., having started working at 17 in the Stephens Mills, later known as the De Witt Wire Cloth Co. He subsequently worked for the Eastwood Wire Co. Developing many special processes for the weaving of wire cloth, Mr. Campbell was a leader in bringing the American manufacture of this product to a high quality. He perfected a spiral weave filter cloth which is now in use throughout the world. Mr. Campbell's son, Leggett C. Campbell, secretary and treasurer of the company, has assumed a large part of the responsibility during the last few years.

Harnischfeger Corp.

THE HARNISCHFEGER CORP., Milwaukee, Wis., announces the appointment of H. S. Strouse as vice-president of the corporation. Along with the duties of his new position, Mr. Strouse will continue to direct the activities of the treasurer's department which he has headed for the past 7 yr.

Mr. Strouse's business activity began in 1915 when he graduated from the school of electrical engineering at Purdue University. After graduation, he entered the Chicago Central Station Institute for approximately a year, following which he was employed by the Interstate Public Service Co., Newcastle, Ind., as new business manager. At the outbreak of the war he entered the first officers' training camp at Fort Benjamin Harrison, Indianapolis, and after active service overseas, with the 310th Regiment of Engineers, was mustered out in 1919. Mr. Strouse then entered the employ of the Western Electric Co. at Chicago as designer in the Automatic Telephone Section. Shortly after this he went to the Harnischfeger Corp. as estimating engineer. In 1921 he was appointed to the position of advertising manager, and in 1931 was elected treasurer of the company. Two years later he became a director of the company.

V. D. Simons

V. D. SIMONS, 66 yr. old, well known consulting engineer of Chicago, passed away March 24 at Tucson, Ariz., where he had gone for the winter because of failing health. He is survived by his widow, two daughters and three sons.

He was born August 1, 1871, in Allegan, Mich., and his natural engineering ability and interest first led him into the paper industry in Kalamazoo. In 1897 he became superintendent and manager of the public utility plant at Battle Creek. He went to Wisconsin Rapids in 1903 to take charge of the design and installation of electrical and hydraulic equipment for the new Consolidated Water Power Paper Company mill. The first variable speed paper machine drive was installed at this mill under his direction. Three years later he became manager of the Biron plant of the company. In 1912, he patented the sectional electric drive for paper machines which

Weather to Order

WEATHER TO ORDER just isn't possible in general, because people don't agree as to what the weather shall be. Picnics and thirsty fields are opposing interests. But when a group agrees on what it wants in a particular spot, the engineer can supply the demand by hot blast, sprinklers, air-conditioning, sun lamps and other means as may be required.

Demand for a ski meet in the Philadelphia Arena required some rather special work. Other indoor ski meets have been held, but to get a satisfactory jump where the height available was only 40 ft. and length available 220 ft. was a different problem. Finally a slide 40 ft. high by 115 ft. long was decided upon, the frame of tubular steel and floor of wood, tar paper, burlap, with lath crosspieces to hold the artificial snow from sliding.

Then the Link-Belt ice crusher-slinger was called in to crush and distribute 71 t. of ice furnished by McGowan Ice & Coal Co. in a 6-in. layer over the ramp and slide. The slide was 20 ft. wide at the top, 30 ft. wide below the take off, which was 14 ft. below the top of the slide and 26 ft. above the arena floor. This gave a fast, interesting jump, even in the limited space, and to add to the interest, a skating floor was provided at the side of the slide. It was found that the entire slide could be iced from a crusher truck at floor level, as shown in the illustration, as the stream of pulverized ice could be thrown 30 ft. from the hose nozzle.

Icing the Philadelphia Arena ski slide

Thus was the ice slinger, whose everyday job is the icing of refrigerator cars and the like, turned to increasing the joy of humanity by making possible a jolly ski meet, skating party, snow-shoe race and winter sports meet. Another illustration of the contribution that the engineer and the application of power is making to the welfare of the country.

has since become an important feature of modern paper making. After participation in other engineering and construction projects on the West Coast and in Wisconsin, he opened an engineering office in Chicago in 1914 and has maintained it continuously since that time.

Technical Magazines for New York Hospitals

MORE THAN 4000 business magazines and other publications have been distributed by the Technical Publicity Assn., New York Chapter of the National Industrial Advertisers Association, among 30 New York hospitals since this service began last October. These go to hospitals serving about 300,000 patients a year, and members of T.P.A. are being urged to telephone the committee, Robert L. Ware, chairman, Hotch Clark, McGraw-Hill Co., and Miss Louise Dykes of J. Walter Thompson, before discarding any publications. Arrangements will then be made for bundling and delivery to the various hospitals whose patients, apparently, are interested in practically every subject.

Jones & Laughlin Steel Co.

CHANGES in organization of Jones & Laughlin Steel Co. of Pittsburgh are announced by Lewis M. Parsons, vice-president and general manager of sales, as follows:

R. T. Rowles, who has been manager of hot rolled sales since 1925, becomes assistant general manager in charge of hot rolled, cold finished, wire products and warehouse sales. W. H. Wiewel, formerly with Cambria Steel Co. and manager of sales of tubular products for J. & L. since 1935, becomes assistant general manager in charge of by-products, pig iron, sheets and strip, tinplate and tubular products. H. J. Watt, sales manager in New York since 1935, is now assistant general manager in charge of New York and the east, including Boston, Philadelphia, Baltimore and Atlanta offices; he is succeeded as manager of hot rolled sales by Arthur A. Wagner, formerly assistant manager of that department. To assist Mr. Watt, John O'H. Anderson becomes New York manager of sales, while William K. Breeze is transferred from Cincinnati and Hughart R. Laughlin from Pittsburgh to New York.

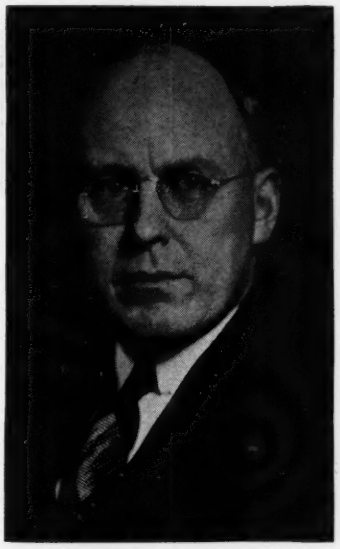
In Boston, F. B. Kittredge will be promoted from the Philadelphia office to work with Samuel A. Fuller, present district sales manager. Philadelphia will be in charge of John B. De Wolf who comes from the Cleveland office of Republic Steel and succeeds Thomas C. Ham, who is transferred to Pittsburgh in charge of the company's industrial training. Herbert B. Spackman, coming from the Buffalo office of Bethlehem Steel Co., will be assistant district sales manager in Philadelphia.

In the new Baltimore district office, V. A. Jevon, formerly with Bethlehem Steel Co., becomes sales manager with H. R Dorney, from Philadelphia, as assistant manager.

In Buffalo, Charles M. Mason, from the Cleveland office becomes assistant sales manager under Charles F. Gold, and in St. Louis, Edward H. Hughes, formerly with American Bridge Co. and later with J. & L in Chicago and Pittsburgh, becomes district sales manager, succeeding J. B. Hungate, who has resigned.

Dan Hirtle, New President Burgess Battery Company

THE BURGESS BATTERY CO. has elected Dan W. Hirtle, President and Dr. C. F. Burgess, Chairman of the Board of Directors at its annual meeting held March 26, 1938. Prior to his association with Burgess, Mr. Hirtle was an assistant superintendent of the American Rolling Mills



Dan W. Hirtle

Company, Middleton, Ohio. With the Burgess organizations, he became general superintendent of the Freeport Burgess plant and rose rapidly to production manager, later vice-president, and now president of the Burgess Battery Company.

Dr. Slepian Associate Director of Westinghouse Research

JOSEPH SLEPIAN, who as a young doctor of philosophy abandoned a promising career in pure mathematics to wind coils for electric motors, has been appointed associate director of the Westinghouse Research Laboratories at East Pittsburgh.

The Westinghouse Electric & Manufacturing Company announced the appointment of Dr. Slepian as an associate to Director L. W. Chubb just 21 years after he started to work as an apprentice in the company's motor division.

Despite the fact that his formal education in higher mathematics included nothing about electrical engineering, Dr. Slepian has become one of the world's outstanding electrical engineers.

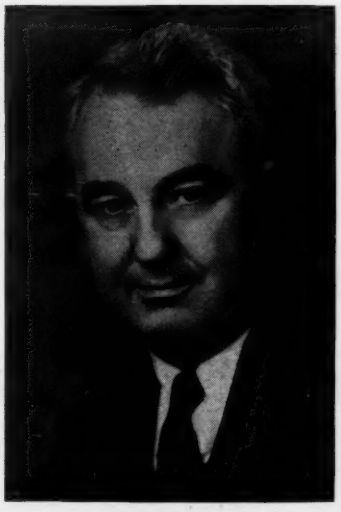
Noted principally for his fundamental researches on the theory and mechanism of the electric arc, which led him to develop the theory of deionization underlying the principle of the De-Ion circuit breaker, Dr. Slepian has many other outstanding accomplishments in electrical engineering to his credit. His keen insight into fundamental phenomena has left its mark not only on circuit breaker practice but also in the field of lightning arrestors, rectification and electronic control.

Joseph Slepian

Born in Boston, Dr. Slepian was graduated from Harvard in 1911 and received his doctor's degree in 1913. This was followed by graduate study abroad in integral and differential calculus, tenser analysis and integral equations.

Hance H. Cleland

HANCE H. CLELAND was elected president and director of The California Oregon Power Co. to succeed Chauncey M. Brewer who died on March 2. Mr. Cleland was graduated from the Central Normal College at Danville, Ind., in 1906



Hance H. Cleland

and practiced law in Oregon and Washington from 1910 to 1936. He was assistant attorney general of the state of Washington from 1916 to 1919, member of the Washington Public Service Commission and its successor, the Dept. of Public Works, 1919 to 1924, and has been valuation and rate counsel for The California Oregon Power Co. for the past 13 yr.

New Westinghouse Engineering Department

THE NEW INDUSTRY ENGINEERING DEPARTMENT of the Westinghouse Electric & Mfg. Co. has been formed to centralize electrical engineering activities of the company relating to central station and industrial power problems. With this unification

of engineering technique, engineers in various fields will benefit by the availability of latest engineering developments affecting their industries.

Mr. C. A. Powel, manager of the department, has announced the department's functions and personnel which follow.

Mr. A. C. Monteith becomes Engineering Manager, Central Station Section. Mr. Monteith has been with Westinghouse since he was graduated from Queens University, Ontario, in 1923. He completed his Westinghouse training in 1924 and at once entered upon central station engineering work.

Mr. R. D. Evans and Mr. C. F. Wagner become consulting transmission engineers. Both are well known in the central station industry and both have been engaged in Westinghouse central station or related engineering work since completing the training course. Mr. Evans is a graduate of the University of Oklahoma, 1914, and Mr. Wagner of the Carnegie Institute of Technology, 1917.

The industrial activities are divided among three sections: the Metal Working Section, with Mr. G. E. Stoltz as Manager; the Mining, Chemical and Petroleum Section, with Mr. Phelan McShane as Manager; and the General Mill and Resale Section, with Mr. C. W. Drake as Manager.

A. C. Montieth

C. A. Powel

Mr. G. E. Stoltz has been with the company since graduating from the Ohio State University in 1909. He has been closely identified with steel mill electrification developments and mine installations of the company.

Mr. McShane joined Westinghouse in 1922, having previously been associated with leading steel, mining and transportation companies. With Westinghouse he has been identified with Westinghouse general and commercial engineering work with the steel, construction and equipment industries.

Mr. Drake is a graduate of Worcester Polytechnic Institute, 1905, and since then has been identified with Westinghouse application engineering work with the miscellaneous industries from headquarters, except for the years 1914-1919, when he was located in the Chicago office.

Mr. H. C. Coleman continues as Manager, Marine Engineering Section.

For the Engineer's Library

Any Catalogs that you wish will be gladly sent. Write Power Plant Engineering.

Instruments

Instruments in Industry—Bringing together instrumentation and machinery for the betterment of industry is the primary purpose of a new house organ which will be issued periodically by the Meter Division of the General Electric Co. The many ways in which electric instruments can bring more and greater benefits to industry are presented and illustrated, and new products are announced in the columns of this periodical. Emergency testing, making plant surveys, testing new equipment, controlling production, and incorporation in the product itself are a few instrument uses in the industrial field. Likewise utilities and transportation companies are finding instruments invaluable in giving customer service. This publication, printed in small newspaper form, is distributed free of charge to industrial plants.

Jim is Right—Folder 80-36 under this title explains how Brown Flow Meters, by metering steam, water, oil and other fluids, can bring to manufacturing processes many of the economies they have effected in power production. It includes several illustrations demonstrating the savings that have been made in the generation and distribution of steam. A copy of this folder will be sent on request to The Brown Instrument Co., Wayne & Roberts Ave., Philadelphia, Pa.

Temperature Measurement—Bulletin 299 on the Ardometer for indicating temperatures when sighted on a hot object. Five ranges covering 1100 to 3700 deg. F. in direct readings. Bulletin 300 on optical pyrometer, adjusting brightness of lamp filament to equal that of hot object. Three ranges covering 1150 to 4800 deg. F. Bachrach Industrial Instrument Co., 7000 Bennett St., Pittsburgh, Pa.

Outdoor and Indoor Service Socket Instruments—Westinghouse Type E socket instruments for outdoor and indoor industrial plants, are described in a 20-page illustrated booklet. The use of these instruments as an accurate and reliable means for determining what takes place in electrical systems are illustrated. Application, economic advantages, construction details and the selection of sockets and accessories are explained. Tabulations and diagrams show styles and list prices. Copies of Catalog Section 43-600 may be secured from Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

When You Can Measure—A 32 page brochure under this title tells in brief the contributions of General Electric engineers and scientists to the important art of measurement. This attractive, beautifully printed publication describes in pictures and in words the story of how instruments are designed, constructed and tested in the "headquarters for electrical measurement." Every development in electricity has grown out of experiments in which instruments played a major part. The incandescent lamp, the electric motor, electric household appliances, radio—none of these commonplaces of modern living would have been possible without the imposing array of ingenious, sensitive, accurate measuring devices engineers have perfected. Since measurement, in its final form, depends upon comparison with some carefully chosen standard, a section of the booklet is given over to a description of the company's standards of voltage, resistance, time, and temperature. General Electric Co., Schenectady, N. Y.

Instruments—Pyrometers and paper testing instruments are briefly described and illustrated in a leaflet issued by Thwing-Albert Instrument Co., 3339-41 Lancaster Ave., Philadelphia, Pa.

Special Testing Instruments for laboratory and factory are covered by a new bulletin of the Commercial Engineering Laboratories, Detroit, Mich. This equipment covers air flow equipment, engine indicators, fuel flow indicators, magnetic gages, Piezo-ray, sound study and vibration study equipment and miscellaneous test instruments.

Meters

Bailey Boiler Meters is the title of a 32-page bulletin containing an analysis of 7000 combustion tests made during the last 12 yr. on all types and sizes of boilers including a full range of fuels and methods of firing. In addition to describing the Bailey Boiler Meter and the ways by which it reduces boiler operating cost, this bulletin shows graphically the average percentage of excess air with which various classifications of boiler units are operating in actual practice. It also shows the percentage occurrence of limiting factors in reducing excess air for combustion under boilers with various types of firing and furnace wall construction. Bailey Meter Co., Cleveland, Ohio.

Power Factor Correction—A new booklet entitled, "We Raised Our Power Factor and Save $900 a Year" written by Harry L. Wilcox and reprinted from Factory Management and Maintenance shows by actual illustration

how a factory can automatically control the power factor between 90 and 95 by means of an E. C. & M. automatic power factor regulator. The Electric Controller & Mfg. Co., Cleveland, Ohio.

Brown Pneumatic Remote Transmission System—This system, described in Folder No. 94-1, was developed by The Brown Instrument Co. for remote transmission of measurement and control in Hazardous atmospheres—where the use of electrical transmission is not permissible. The system's principle of operation and the simple, rugged construction of the transmitting unit are illustrated by schematic diagrams. A copy of this folder will be sent on request to The Brown Instrument Co., Wayne and Roberts Ave., Philadelphia, Pa.

Automatic Controls — Thermovalve, Lever-Action Dual Solenoid Valve, Sensitive AC Relay, Refrigerant Valve with Sweat-type Connections, Sensitive DC Relay and Lever-Action Solenoid Valve are illustrated and described in a 6-page folder issued by General Controls, 267 5th Ave., New York, N. Y.

Boiler Accessories—Three new pieces of literature dealing with devices used to maintain and check boiler water levels have been issued by L. J. Bordo Co., Glenside, Pa. One is entitled Bordo Feed Water Regulator in which the salient features of this regulator are illustrated and described; the second deals with the Bordo water column and the third with the Bordo safety water gage.

Swartwout Pressure Controls—Illustrated with photographs, line drawings, cross sections showing details of construction, and hook-up diagrams, all with appropriate descriptive text, this new Bulletin S-22-B dealing with equipment for maintaining constant pressure—differential control, variable pressure—combined controls, and pump controls is an interesting and valuable treatise on the company's control specialties. The Swartwout Co., 18511 Euclid Ave., Cleveland, Ohio.

Packing

Mechanical Packings—A new complete manual and data book on mechanical packings has recently been published. Reference to this manual will enable any user of packings to select, quickly and easily, the manufacturer's recommendation of the kind and type of packing best suited to his service and conditions. The jobber and his salesmen will find it a complete catalog of mechanical packings for every industrial service. Sizes, weights, footage, together with standard packaging are given. Packings are fully illustrated and described in detail, supplemented by a carefully compiled chart of service recommendations which is an invaluable sales help to the supply salesman. Linear Packing & Rubber Co., Inc., Philadelphia, Pa.

John Crane Packing is the subject of a new circular on packings for reciprocating and centrifugal hot and light oil pumps with hard and medium hard steel plungers and valve stems. Large illustrations and concise descriptions, with engineering data, conveniently arranged, make this circular a handy guide to better packing service. Crane Packing Co., 1800 Cuyler Ave., Chicago, Ill.

Garlock Split-Klozure is the subject of a new catalog which describes and illustrates the new type of sealing ring. The Garlock Packing Co., Palmyra, N. Y.

A new simplified packing recommendation chart which provides a simplified, accurate method of determining correct packings for specific jobs, covers from 90 to 100 per cent of all normal packing requirements, has been announced by New York Belting & Packing Co. Service recommendations include: high pressure steam, low pressure steam, hot water, cold water, ammonia, brine, air, gasoline, oil up to 400 deg. F., and oil over 400 deg. F. Charts are available at no cost through any of the company's distributors or can be obtained by writing New York Belting & Packing Co., No. 1 Market St., Passaic, N. J.

Water Treatment

The Inside Story of Boiler Water Conditioning—A new edition of a booklet under this title contains a new approach to the boiler water conditioning problem that will be of unusual interest. The purpose of the treatise is to explain in simple non-technical terms the conditions most frequently encountered and to discuss the various methods of softening, treating water, and removing concentrations from the boiler. A copy may be obtained by writing the Elgin Softener Corp., Elgin, Ill.

Water Supply Systems—Bulletin 260-B13C is devoted to a pictorial presentation of the various services for which Roots-Connersville water systems are suitable. It describes units with capacities ranging from 300 to 2700 gal. per hr. Roots-Connersville Blower Corp., Connersville, Ind.

Permutit Floc-former is the subject of a catalog which describes in general the subject of coagulation and the features of the Permutit Floc-former. The Permutit Co., 330 West 42nd St., New York, N. Y.

Engines and Motors

Motors—Three new bulletins treating this subject have been issued. The bulletin entitled Streamline Protection describes the U. S. Standard horizontal uniclosed motor and shows the method of ventilation provided in U. S. motors. Asbestos Protected is the title of the bulletin which describes the method used in insulating and winding U. S. motors. The Autostart Grinder bulletin enumerates and illustrates the various features of the Auto start Grinders and Buffers. U. S. Electrical Motors, Inc., 200 E. Slauson Ave., Los Angeles, Calif.

Two Pole Squirrel Cage Motors—Bulletin 2287. A well illustrated leaflet deals with high speed motor applications to such service as pumps and blowers in a variety of types covered by standard sizes ranging from 1½ to 2500 hp. A copy may be obtained from Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Diesel Engines—Made in V type with 8 cylinders for the largest sizes and in 6 and 4 cylinder straight line types, these Caterpillar engines cover the range from 44 hp. at 1400 r.p.m. to 160 hp. at 850 r.p.m. The 32-p. catalog gives curves of characteristic performance, shows details of construction and arrangement, and tabulates specifications and principal dimensions. It is Bulletin C-12 Form 4253, issued by Caterpillar Tractor Co., Peoria, Ill.

Piping

Wrought Iron for Piping Systems—A new bulletin under this title discusses pipe materials; costs; pipe selection; why some metals resist corrosion better than others; water supply, drainage, heating and power systems; and a section devoted to installation procedure. The publication contains 40 pages, many of which are illustrated with piping installations.

It also contains an appendix of statistical data regarding the life of various pipe materials in specific installations. Copies of this bulletin may be obtained from A. M. Byers Co., Pittsburgh, Pa.

Expansion Joints—Bulletin 100 briefly describes and illustrates the various kinds of Badger Packless expansion joints, and discusses the improvements brought out by the company's engineers. It includes list prices and dimensions of the product. E. B. Badger & Sons Co., Boston, Mass.

Dresser No-Thread Fittings—A new 16-page booklet describes the features of these unique types of self-contained pipe joints that connect pipe without threading. S. R. Dresser Mfg. Co., Bradford, Pa.

Hancock Steel Valves is the subject of Bulletin 5-7000 which describes Hancock's redesigned line of forged and cast steel valves. Hancock Valve Division, Manning, Maxwell & Moore, Inc., Bridgeport, Conn.

Calculation for Pipe Wall Thickness. Based on A.S.T.M. Specifications and A.S.A. Code for pressure piping, this 12-page Bulletin 37-A gives a simplified method for calculation of pipe wall thickness for various pressures and temperatures. Four tables and a chart of comparison of standards for pipe wall thickness are included. Table I covers pipe in power piping systems, Table II pipe in gas and compressed air systems, Table III pipe in oil piping systems and Table IV seamless alloy steel pipe. A complete discussion on how to make use of these tables is included. Bulletin 37-A is issued by the Midwest Piping & Supply Co., Inc., 1450 S. Second St., St. Louis, Mo.

Mechanical Power Transmission

Pressure Lubrication Without Special Fittings is the title of an attractive folder which illustrates and describes the Acco-Morrow Pressure Lubricator. It shows how pressure lubrication is possible even with common oil holes and without the use of any special fittings because of the "oilingseal" tip which is an integral part of the lubricator. The Acco-Morrow Pressure Lubricator is made in ten styles—including an oiler type which provides pressure of over 500 lb. and a gun type which gives a pressure of 1000 lb. American Chain & Cable Co., Inc., York, Pa.

Belt Conveyor Idler—New line of Timken bearing idlers with bearings adjusted at the factory but rolls to be mounted in the field. Bulletin No. 80 gives description, prices, dimensions and weights. C. O. Bartlett & Snow Co., Cleveland, Ohio.

Belting—Costs of belting in several industries and a method of keeping a record of cost of transmission belt are given in an article in March Research issued by E. F. Houghton & Co., 240 W. Somerset St., Philadelphia, Pa.

The Hydrovolifier, used for the purpose of cleaning, dehydrating and degasifying oils used in transformers, regulators, compensators, switches, cables and bushings, is illustrated and described in a folder issued by The Buckeye Laboratories, Inc., Alliance, Ohio.

Making Dirty Oil Come Clean is the subject of a reprint from the house organ Research, Illustrated. It may be had from E. F. Houghton & Co., Third, American and Somerset Sts., Philadelphia, Pa.

Sleeve Bearings—Folder of sheets describing graphited, laminated and sheet metal bearings, also discussing bearing alloys and bearing lubrication. Johnson Bronze Co., New Castle, Pa.

Electrical Equipment

Varnished-cambric Insulated Cable—This 32-page bulletin (GEA-2623) supplies information on the types available, their construction and characteristics, and the applications for which they may be best adapted. It also includes simplified data on how to select conductor size. The part of the subject matter dealing with standard cable types is treated broadly under the three major heads of conductor, insulation, and finish—the three main constituents of an insulated cable. Those types which are generally considered as special for cerain applications, such as line wire and apparatus leads, are described under separate headings. General Electric Co., Schenectady, N. Y.

Electrical Equipment—Leaflet 2124-A illustrates and describes Type ARZ enclosed, fan cooled motors. Switchboards are discussed in Bulletin 1190. Distribution transformers is the subject of Leaflet 2289 and Bulletin 1829A is entitled small electric hoists covering both single and double drum types. Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Dunco Relays—A new 32-page catalog D under this title describes and illustrates the different types of relays and the application and design features of each. Struthers Dunn, Inc., Philadelphia, Pa.

Electrodes—A complete line of shielded-arc welding electrodes are described in a pocket-size folder issued by the McKay Co., McKay Bldg., Pittsburgh, Pa.

Distribution Transformers—Bulletin 2172-B covers the construction of the Company's type CB distribution transformers built for 6900 and higher voltage classes. It devotes considerable space to improved impulse strength and other features that assure convenient, economical and trouble free operation. Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Welder—Bulletin No. 327 gives specifications of Lincoln Shield-Arc SAE welder, consisting of Diesel engine, generator and controls with storage battery and starter. Lincoln Electric Co., Cleveland, Ohio.

Electric Equipment—Fifteen new bulletins on the following subjects have been issued by the General Electric Co.: GEA-432C Direct-Current Generators and Exciters; GEA-2630 New G-E Dew-Point Potentiometer; GEA-841H A-C Magnetic Switch; GEA-1283A G-E Cam-operated Master Switches; GEA-2742 Pyranol Capacitors; GEA-2822 Small Panel Instruments; GEA-2821 The Better Switchboard Instrument; GEA-2825 Laboratory and Specialty Instruments; GEA-2824 Commercial Testing Instruments; GEA-1297B Electric Cable-Reel Equipment; GEA-2716 D-C Cam-Type Drum Switches; GEA-1929A G-E Gear-Motors; GEA-2823 Commercial Testing Instruments GEA-2003B Automatic Oil Circuit Recloser; GEA-2170A Directional Distance Relays.

Materials

Moldit Refractory Cements developed for industrial use at temperatures up to 2800 deg. F. are described and illustrated in Bulletin R-33 which has just been issued by the Refractory and Insulation Corp., 381 Fourth Ave., New York, N. Y.

Summary of Light Reflectivity—The analysis, completed by the Robert W. Hunt Engineering Laboratories, shows the light reflectivity of such materials as brick, wood, concrete, insulating board, and metal before and after painting with Valdura Mill Whites. It further indicates the decreased lamp wattage required to furnish adequate illumination

Quality Stokers for Forty Years

AUTOMATIC STOKERS were almost a curiosity when the Detroit Stoker Co. was established in 1898. Engineers and firemen had to be educated to the stoker idea and boilers were then wastefully fired by hand. Today, however, stoker equipment is considered as an absolute necessity in the interest of eliminating waste and smoke from boilers. Progress of design and application in the first mechanical stokers was slow and operating difficulties were encountered with the use of the early stoker designs. The industry survived only because of the fortitude and vision of its leaders and the great economy which stokers have brought about in the conservation of fuel is well known.

This year the Detroit Stoker Co., which has contributed a great deal to the art of coal burning, is celebrating its Fortieth Anniversary. From a small beginning in a very modest factory in Detroit, it has grown to one of the largest concerns in the industry and through the years has developed many stokers since the early beginning and building of the Detroit V-Type stoker.

Changing coals and changing load conditions have made it necessary for this company to be prepared to fulfill the needs as they arose. Many types and sizes of both underfeed and overfeed stokers, of which many thousands of installations have been made in all parts of the United States, Canada and Europe have been developed.

The manufacturing facilities of the Detroit Stoker Co. at Monroe, Mich. (near Detroit), are the finest of modern equipment and are devoted to stoker manufacture exclusively. They include a plant having a large modern foundry, with core ovens and cleaning department, fully equipped to produce the highest grade castings. Parts which are subjected to the heat of the furnace are made of a special mixture of iron. Thoroughly up-to-date machine and assembly shop where all stokers are completely assembled prior to shipment are also located at Monroe. Detroit stokers for Canada are built in London, Ontario.

This company maintains a staff of trained service men and erecting engineers, who go through a course of study in the engineering and manufacturing departments before being sent out to supervise the erection of stokers. Extreme care is exercised by these men to see that the equipment is properly handled, installed and placed in operation, and the permanent operator is carefully instructed. It is the policy of the company to visit periodically all plants where Detroit stokers are in operation, to instruct new operators.

Through these 40 yr. the Company has maintained policies carefully adapted to the power plant field which it has served with quality coal burning equipment.

after mill white paint is applied. A copy of the summary on light reflectivity will be sent on request to American Asphalt Paint Co., 43 East Ohio St., Chicago, Ill.

Refractory Cement—For laying fire brick in industrial and boiler furnaces, Q-Chrome, having neutral characteristics, resistance to high temperatures and durability against flame penetration is described in Bulletin 322-B issued by Quigley Co., 56 W. 45th St., New York, N. Y.

Copper-Nickel Castings—Production of pressure-tight castings from 70:30 copper-nickel alloy is discussed in a paper presented before American Foundrymen's Assn., which covers foundry procedure, the effects of other elements such as iron, zinc, aluminum and tin, and gives the composition and physical properties of the 30-per cent cupronickel. Reprints are available as Bulletin No. 404 from International Nickel Co., Inc., 67 Wall St., New York, N. Y.

Pumps and Compressors

Steam Jet Ejectors is the subject of bulletin 9046 covering single, two, and three-stage jet ejectors for removing air, gas, or vapors from condensers and vacuum chambers in industrial processes. Features of this type of vacuum pump include the ability to handle any quantity of wet or dry mixtures at any vacuum, high sustained efficiency, low initial and maintenance cost, and economical trouble-free operation. This 28-page bulletin explains the application and characteristics of ejectors and illustrates the operation and arrangement of all types of ejectors with either surface or barometric precoolers, inter and after-condensers. Copies of bulletin 9046 may be obtained from the Ingersoll-Rand Co., 11 Broadway, New York, N. Y.

Turbo Blowers is the subject of bulletin 1911 describing single stage turboblowers of the overhung type, pedestal type and double inlet type, built for capacities from 600 c.f.m. to 10,000 c.f.m., for air pressures from 1 to 6 lb. G. It can be obtained from the Blower and Compressor Division, Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Pumps—Uses for all purposes and recent refinements in design of single and multi-stage centrifugal pumps for large and small capacities are discussed and illustrated in a 16-p. booklet issued by De Laval Steam Turbine Co., Trenton, N. J.

Compressed Air Cooler—In Bulletin A-21 are described Series P aftercoolers for compressed air and gases, which are available in six sizes, 125 to 755 c.f.m. They have moisture and oil separator and are installed as part of the pipe line. Sullivan Machinery Co., Michigan City, Ind.

Centrifugal Pumps—This 50-page, Bulletin 1651-A, well illustrated with well over 100 photographs describes centrifugal pumps including a type for every purpose. Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Calyx Core Drills—A new 42-page catalog, 9501-A, on the complete line of Calyx Core drills. This type of drill is designed for boring holes in rock and concrete in sizes from 2¼ to 72 in. in dia. and depths of 2500 in. The catalog lists 17 models for all classes of service, including laboratory testing, highway testing, mine ventilation shaft drilling, foundation testing, well drilling, elevator-plunger-hole drilling, mineral exploration, oil structure exploration, waterfront construction, and wire-saw equipment-shaft drilling in quarries. Ten pages are devoted to pictorial representation of some of these applications in all parts of the world. Copies may be obtained from Ingersoll-Rand Co., 11 Broadway, New York, N. Y.

Miscellaneous

Johns-Manville Bonded Built-Up Roofs—A book under this title has recently been revised to include information on the latest types of built-up roofing; and now contains, within its 36 pages, more than 40 complete detailed specifications on J-M Built-Up Roofs. Twenty-two pages are devoted to these specifications, and plentiful drawings illustrate the manner in which the roofing materials are applied to various types of roof decks. A feature of the revised edition is a newly organized table of condensed specifications which is a convenient source of quick and accurate information. Copies of this book are available upon request to Johns-Manville, 22 East 40th St., New York, N. Y.

Water Works Ownership in the United States is the title of a booklet which was prepared with the idea that it will be helpful to city officials seeking information on water property ownership and operation. It includes the results of a nation-wide survey on water property ownership and other information of interest. Burns & McDonnell Engineering Co., Kansas City, Mo.

Ventilating Equipment—South Bend Dynaflow and Aerospot ventilating equipment is illustrated and described in Catalog No. 1A of the South Bend Air Products, Inc., South Bend, Ind.

Industrial Safety Devices—A new catalog covers the complete Willson line of eye, nose, throat and lung protectors. Included are more than 50 types of goggles for every conceivable purpose, a dozen welding handshields and helmets, seven United States Bureau of Mines approved types of dust respirators, air line respirators, abrasive helmets, etc. Copies may be obtained from Willson Products, Inc., 296 Thorn St., Reading, Pa.

Anniversary Bulletin and List of Exhibits—This bulletin gives a brief history of the company celebrating its 25th anniversary at one location. It includes pictures of the entire plant. Western Precipitation Corp., 1016 West Ninth St., Los Angeles, Calif.

New Engineering Books

Differential Calculus. By S. Metra and G. K. Dutt. Published in England by W. Heffer & Sons, Ltd., Cambridge. Exclusive distributors in North and South America, The Chemical Publishing Co. of N. Y., Inc., 148 Lafayette St., New York, N. Y. Size 5 by 7½ in., 302 pp., cloth bound. Price $4.00.

Mathematics is an engineering tool and although the practicing engineer does not need to be an accomplished mathematician, it is almost necessary for him to have some understanding of calculus if he is to follow and understand technical progress in his field. This book has been arranged so as to make it possible for the ordinary reader, with an elementary knowledge of algebra and trigonometry, to follow the work without much expert guidance.

Mathematics can be learned only by doing and the examples (answers are given in the back of the book) or problems have been chosen with the needs of the engineering and science student in mind. A companion volume to be published later will deal with integral calculus and a goodly portion of that volume will deal with applications of calculus to physics, chemistry and engineering.

Air Conditioning—Furnaces and Unit Heaters. By J. Ralph Dalzell. Published by the American Technical Society, Drexel Ave. at 58th St., Chicago, Ill. Size 5½ by 8½ in., 421 pp., cloth bound. Price $3.00.

Although this book deals primarily with domestic air conditioning, it contains a wealth of practical material, not only on the engineering principles involved, but, in explaining them simply and showing how things are actually done. Many of the chapters, such as gravity furnaces, mechanical warm air furnaces, etc., deal only with household service, but, most of the chapters discuss such things as the principles of ventilation, heating and cooling loads, transmission coefficient tables, insulation, air conditioning principles, electric heating, humidification, unit heaters and automatic controls and are as applicable to industrial as they are to domestic work. The book should meet a real need for those who have had considerable experience in the field of air conditioning, as well as for those just entering the field. A large scale psychrometric chart, the use of which is fully explained in the book, is inserted on the inside back cover in such a way that it can be removed for practical use.

Heating, Ventilating and Air Conditioning Guide 1938. Published by the American Society of Heating & Ventilating Engineers, 51 Madison Ave., New York, N. Y. Size 6 by 9 in., 840 pp. plus, 428 pp. catalog section and membership list, flexible fabricoid binding. Price $5.00.

This is the 16th edition of the official reference book compiled by the society and published for engineers, architects, contractors, schools and colleges, purchasing agents, manufacturers, public utilities and others engaged in the field of heating, ventilating and air conditioning. Some 45 chapters cover design and specifications of heating, ventilating and air conditioning systems. Important new material which has been added on the cooling phases of air conditioning practice,, includes extensive revisions of chapters on Refrigerants and Air Drying Agents, Cooling Load Determinations and design of Central Systems for Cooling and Dehumidifying. Noteworthy is the fact that a chapter on Air Conditioning in the Treatment of Disease appears for the first time.

In addition to the technical material, over 300 pages of manufacturers catalog data are included, as well as an index to modern equipment listing 300 items, cross-indexed as to product and manufacturer.

Power Plant Construction News

Calif., Glendale—City Council has authorized plans for new municipal electric power plant, with initial capacity of about 15,000-kw. Cost estimated over $1,000,000, including transmission lines and power sub-station facilities. Proposed to have new station ready for service in 1939. E. A. Ingham is city manager, in charge.

Calif., Oleum—Pacific Gas & Electric Co., 445 Sutter Street, San Francisco, Calif., plans new steam-electric generating plant at Oleum, primarily for service for oil refinery of Union Oil Co. of California at that place. Cost close to $5,000,000, including transmission line and power substation facilities. Application has been made for permission.

Calif., Redding—Bureau of Reclamation, Sacramento, Calif., will receive bids until June 1 for construction of Shasta dam and hydroelectric generating plant, Central Valley Project, about 14 miles from Redding, including installation of penstock and outlet pipes, trashracks, pipe and tubing, electrical conduit, cable, etc. (Specifications 780).

Iowa, Knoxville—Construction Service, Veterans' Administration, Washington, D. C., will receive bids until May 31 for new boiler plant (Building No. 77), at institution at Knoxville, totaling 145,000 cu. ft., including boiler units and complete boiler house equipment, radial brick stack and outside electrical work, as per specifications on file.

Iowa, New Hampton—City Council has authorized plans for extensions and improvements in municipal electric power plant, including installation of new diesel engine-generating unit and auxiliaries, cooling tower, fuel oil tanks and other equipment. Cost about $100,000. Ralph W. Gearhart, Cedar Rapids, Iowa, is consulting engineer.

Kan., Lawrence—Kansas Electric Power Co., Lawrence, has asked bids for erection of superstructure for new steam-electric power plant on site near city, and will begin work soon. Plant will be equipped for initial capacity of 10,000-kw. Cost close to $1,000,000. Sargent & Lundy, Inc., 140 South Dearborn Street, Chicago, Ill., is consulting engineer.

Ky., Owensboro—City Council has engaged Black & Veatch, 4706 Broadway, Kansas City, Mo., consulting engineers, to make surveys and estimates of cost for extensions and improvements in municipal lighting plant and waterworks station, including installation of additional equipment.

La., Bossier City—At special election on April 5, citizens defeated a proposal to issue bonds for $300,000 for a municipal electric power plant and system, and $100,000 for natural gas distributing system, recently referred to in these columns, and projects will not be carried out at this time.

La., Napoleonville—Aron & Co., 416 Poydras Street, New Orleans, La., plan installation of electric power equipment in connection with rebuilding of Supreme Sugar Refinery, near Napoleonville, recently destroyed by fire. Entire project will cost over $350,000. Leo S. Weil and Walter B. Moses, 427 Peters Street, New Orleans, are consulting engineers.

Mass., Worcester—Norton Co., New Bond Street, plans installation of electric power equipment in new four-story and basement addition to abrasive materials and refractory products plant. Work on superstructure will begin soon. Entire project will cost about $275,000. Adolph Johnson, 16 Norwich Street, Worcester, is architect.

Mich., Detroit—Purchasing and Contracting Officer, Quartermaster Corps, Fort Wayne, Detroit, will receive bids until May 13 for 14 automatic coal stokers (Circular 954-25).

Mich., Hancock—City Council has approved plans for remodeling and improving former municipal power house, and installation of equipment for a municipal cold storage and refrigerating plant. Cost about $40,000, including machinery. Financing has been arranged through Federal aid. Albert L. Ehler is city engineer.

Mich., Milford—Ford Motor Co., Dearborn, Mich., has plans under way for new hydroelectric power plant for service at works at Milford. No estimate of cost announced. Shreve, Anderson & Walker, Marquette Building, Detroit, Mich., are engineers.

Minn., Albert Lea—Albert Lea Food Products Co., manufacturer of condensed milk, etc., plans installation of power equipment in connection with rebuilding of four-story grain elevator, recently destroyed by fire. Also will install hoisting, conveying and other mechanical-handling equipment. Loss over $100,000.

Minn., Mora—City Light and Power Commission, Mora, will take bids soon for new engine unit and auxiliary equipment for installation in municipal electric power plant. Burlingame, Hitchcock & Estabrook, Sexton Building, Minneapolis, Minn., are consulting engineers.

Mo., Chillicothe—Board of Public Works will take bids soon, closing about May 17, for extensions and improvements in municipal electric power plant, including installation of new boiler unit and accessories, switchboard, instruments, etc. Entire project will cost about $300,000. Henrici-Lowry Engineering Co., West Tenth Street Building, Kansas City, Mo., is consulting engineer.

N. Y., Ithaca—New York State Electric & Gas Corporation, Ithaca, is arranging fund of $2,903,000 through note issue, proceeds to be used for expansion and improvements in plants and system, including transmission and distributing lines, power substations and other structures.

N. Y., Syracuse—National Biscuit Co., 449 West Fourteenth Street, New York, N. Y., plans installation of power equipment in new baking plant at Syracuse. Traveling ovens, conveyors and other mechanical equipment will be installed. Entire project is reported to cost over $300,000.

N. C., Burlington—Wilson Finishing Mills, Inc., plans installation of electric power equipment in new one-story addition, 70x110 ft., to dye and finishing mills. Entire project will cost about $40,000. E. M. Long is general manager.

N. C., High Point—Adams-Millis Corporation, High Point, plans installation of electric power equipment in new addition to hosiery mill. Entire project is reported to cost about $40,000.

Ohio, Hillsboro—Globe Chair Co., plans installation of electric power equipment in connection with rebuilding of portion of plant, recently destroyed by fire. A new boiler house will be built. Entire project is reported to cost over $45,000.

Ohio, Toledo—Libbey Glass Co., Ash Street, plans installation of electric power equipment in new four-story and basement addition to table glassware plant, for which superstructure will begin soon. Cost over $400,000. Company is a subsidiary of Owens-Illinois Glass Co., Toledo. John H. Wright is president.

Okla., Ponca City—Continental Oil Co., Ponca City, plans installation of compressors, boilers, pumping machinery and other equipment in new natural gasoline plant in Kemp-Munger-Allen oil field district, Wichita County, Tex. Plant will be equipped to process about 15,000,000 cu. ft. of gas per day. Entire project will cost over $100,000. Work is scheduled to begin soon.

Pa., Philadelphia—George D. Wetherill & Co., Front and Cherry Streets, plans installation of power equipment in connection with rebuilding of portion of paint-manufacturing plant, recently destroyed by fire. Loss estimated close to $100,000.

Texas, Arcadia—Dairy Farmers' Co-Operative Association of Galveston County, Arcadia, plans extensions and improvements in refrigerating and cooling plant, including installation of new condensing unit and other equipment. Cost estimated close to $30,000.

Texas, Temple—Brazos River Conservation and Reclamation District, Temple, has made application to Federal Power Commission for permission to proceed with construction of Possum Kingdom dam and hydroelectric power development on Brazos River. Entire project will require about 30 months for completion and is estimated to cost $7,500,000, of which $4,500,000 will be secured through Federal aid.

Va., Richland—W. E. Mullins Lumber Co., plans installation of electric power equipment in connection with rebuilding of portion of mill recently destroyed by fire. A new boiler house is proposed. Fire loss totaled close to $50,000.

Wis., Fond Du Lac—Giddings & Lewis Machine Tool Co., Doty Street, plans installation of electric power equipment in new additions to plant, comprising two one-story units. Work will be placed under way at once. Cost close to $50,000.

Wis., Hudson—Willow River Power Co., plans extensions and improvements in power plant, with installation of additional equipment. Cost about $84,000. Application has been made to arrange financing to provide fund for work.

Wis., La Crosse—Northern States Power, Eau Claire, Wis., has acquired tract of land on French Island, La Crosse, as site for new steam-electric generating plant, on which work is scheduled to be carried out in 1939. Plant will be equipped for an initial capacity of about 30,000-kw., and is estimated to cost about $1,500,000, with transmission lines.